U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION, THOMAS F. HUNT, DIRECTOR; CHARLES F. SHAW, IN CHARGE SOIL SURVEY.

SOIL SURVEY OF THE PASADENA AREA, CALIFORNIA.

BY

E. C. ECKMANN, OF THE U. S. DEPARTMENT OF AGRICULTURE, IN CHARGE, AND C. J. ZINN, OF THE UNIVERSITY OF CALIFORNIA.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1915.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., February 24, 1917.

SIR: In the extension of the soil survey in the State of California during the field season of 1915 a survey was undertaken in the Pasadena area. This work was done in cooperation with the University of California, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this work and to request their publication as advance sheets of Field Operations of the Bureau of Soils for 1915, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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MAP.

Soil map, Pasadena area sheet, California.

SOIL SURVEY OF THE PASADENA AREA, CALIFORNIA.

By E. C. ECKMANN, of the U. S. Department of Agriculture, In Charge, and C. J. ZINN, of the University of California.—Area Inspected by MACY H. LAPHAM.

DESCRIPTION OF THE AREA.

The Pasadena area, situated in southern California, includes the San Gabriel Valley and that part of the Cucamonga Plains lying west of Ontario, together with parts of the lower slopes of the adjacent San Gabriel Mountains to the north, of the San Rafael Hills on the west, and of the Puente Hills on the south. The eastern boundary of the area is formed by the meridian of 117° 40′ west longitude. The area lies partly in San Bernardino County, but mainly in Los Angeles County. A small part of the area at the north is included in the Angeles National Forest. The Pasadena area comprises approximately 423 square miles, or 270,720 acres.

FIG. 1.—Sketch map showing location of the Pasadena area, California.

The physiographic features of the area include high mountains, low hills, plains, and valleys. The San Gabriel Valley lies in a basin inclosed between high mountains on the north and low hills on the west, south, and east. In the east the area includes the western part of the Cucamonga Plains, lying between the San Gabriel Mountains on the north and the Puente Hills on the southwest. The San Jose Hills form the barrier separating the San Gabriel Valley on the west from the Cucamonga Plains to the east. Easy communication between these two principal divisions is afforded by the low, wide pass north of the San Jose Hills and by the long headwater valley of the San Jose Creek to the south.

On the north the area includes part of the lower slopes of the rugged San Gabriel Mountains, which in general trend east and west. These mountains attain an elevation of about 6,000 feet above sea level. They are dissected by numerous large canyons that open into the main valleys. Their slopes are usually steep and are partly covered with forest, but supply some pasturage.

The Puente Hills extend from the southwestern corner of the area in a southeasterly direction toward the Santa Ana River, which follows a course to the southeast, outside the area. These hills are represented by only a narrow spur in the western part of the area, but broaden out toward the southeast. They are rolling, with moderately smooth slopes, treeless, and include land suitable for grain growing and pasturing. They reach elevations of 1,000 to 1,400 feet above sea level.

The San Rafael Hills, which form part of the western boundary of the area, are generally rough and covered with a brushy growth. These hills are not used for agriculture. The San Jose Hills and some outlying associated ridges and spurs lying wholly within the area, attain elevations of 1,300 feet or more above sea level. These hills have moderate slopes, similar to the Puente Hills, and like them include land suitable for grain production and for pasture. The San Jose Hills in their eastern extremity are rough and stony and are but little used for agriculture.

The San Gabriel Valley is the most important agricultural section of the area. It consists of broad, occasionally dissected, alluvial fans that descend with decreasing slope from the steep and rugged mountains on the north and from the Puente and San Jose Hills on the south and east toward the main channel of the San Gabriel River. The San Jose Valley is an important tributary to the San Gabriel Valley, which it joins at Puente. La Canada Valley is a high, partially isolated valley in the extreme northwestern part of the area.

That part of the Pasadena area lying east of the San Jose Hills and including the western extremity of the Cucamonga Plains is very similar to the San Gabriel Valley in general topography. The alluvial fans extend southeastward from the mountains on the north and from the San Jose Hills on the west toward the course of the Santa Ana River.

There is a wide range in elevation within the area, with extremes of 234 feet above sea level near La Puente School, in the southern part, and of over 2,000 feet just north of La Crescenta, in the northwestern part. The elevation above sea level at Pasadena is 850 feet, at Sierra Madre 1,000 feet, and at Lordsburg 1,059 feet.

The Pasadena area as a whole is well drained. The surplus waters from a large extent of mountain land to the north and hill land on the west and east and from the area itself are disposed of through three principal drainage systems. The San Gabriel River drains most of the area. The Arroyo Seco is the main drainage way in the extreme western part, and Chino Creek in the eastern part.

Some of the larger streams of the area carry water the year round throughout their courses, but the greater number are intermittent.

Streams issuing from the canyons in the high mountains at the north in some cases disappear in the valley sands and in other cases are diverted for irrigation purposes. While the drainage systems are able to handle the ordinary run-off from the mountains and valleys, an unusual amount of precipitation results in damaging overflows.

The Pasadena area lies in a densely populated section of southern California, and the population is rapidly increasing. As the survey is not coextensive with any civil division, the exact population can not be stated, but the density of population is probably about that of Los Angeles County, which, according to the census of 1910, is 124 persons to the square mile, or considering only the rural population, 22.7 persons to the square mile. The inhabitants are chiefly native whites. The more important foreign nationalities represented, in the order of their numbers, are German, Canadian, English, and Mexican. In general, the inhabitants of other extraction live in the larger cities and towns.

Owing to the attractive natural conditions the western, northwestern, and northern parts of the area comprise many cities and towns. As far east as Eaton Wash, from the mountains at the north to the low hills on the south, the western part of the area has been platted into city and town lots. From Eaton Wash to Claremont incorporated cities extend over the mountain foot slopes and alluvial fans in an almost continuous belt. Much of the land between the corporate limits of the cities and towns is used for sites for residences, hotels, and sanitariums. These frequently are located high up on the mountain slopes or well back in the canyons.

Pasadena, with a population of 30,291,[1] situated in the western part of the area, is the principal city. It is the chief commercial center and also is noted for its tourist accomodations and fine residences. South Pasadena, with a population of 4,649, adjoins Pasadena on the south. It is chiefly a residence city. Alhambra, lying next to South Pasadena, is another attractive residential city, with a population of 5,021. Extending south from Alhambra to the foothills is Ramona, one of the new residential centers of the area. San Gabriel lies east of Alhambra; a large part of the population of this town consists of Mexicans.

Sierra Madre, with a population of 1,303; Monrovia, with 3,576 inhabitants; Azusa, with 1,477; Lordsburg, with 954; and Claremont, with 1,114, as well as Duarte, Glendora, San Dimas, and Arcadia, are situated in the northern foothill belt. These towns are centers of the citrus-fruit industry and nearly all have fruit-packing plants.

[1] Statistics of population are taken from 1910 census.

Pomona, situated in the eastern part of the area, is the second largest town, with 10,207 inhabitants. It is an important commercial place and the center of an extensive citrus-growing district. Chino, with 1,444 inhabitants, also situated in the eastern part of the area, has a large beet-sugar factory. Covina, with a population of 1,652, is situated in the center of the area. A large citrus-fruit district has been developed about this town. Puente, Elmonte, Savannah, and Walnut are the centers of the walnut, grain, alfalfa, and truck producing districts of the area. Montrose, La Crescenta, and La Canada are small towns or rural communities in La Canada Valley.

Besides the places enumerated, a small part of the city of Los Angeles lies within the area, and many small villages and shipping stations are found along the railroads.

A network of steam and electric transportation lines reaches nearly all parts of the area. The main lines of the Southern Pacific; the Atchison, Topeka & Santa Fe; and the Los Angeles & Salt Lake systems traverse it in a general east and west direction. The Pacific Electric Railway Co. operates a system of electric lines that connects all parts of the area with Los Angeles and other cities and towns.

A public-road system including main highways of model construction connects the principal centers of population, and easy transportation by automobile or horse-drawn vehicles to all parts of the area is available. The roads can be traveled at all seasons of the year, and regular routes of travel have been established by motor vehicles between the principal centers. The motor vehicle has replaced the horse to a great extent, and much of the hauling that was formerly done by railroads is now done by motor trucks.

Los Angeles and other southern California centers of population, in addition to the cities and towns within the area, constitute the chief local markets for the agricultural products. The citrus-fruit and nut production is distributed throughout the United States and other countries. There is a ready local market for hay, truck, and dairy and poultry products. The sugar beets grown are disposed of within the area. Fruit-packing houses, canneries, and various factories are numerous.

CLIMATE.

The climate of the Pasadena area, like that of southern California in general, is subtropical and semiarid, and is characterized by a wet and a dry season. Pleasant weather prevails throughout almost the entire year. The days in summer and fall are moderately warm, but the nights are cool. During the winter and early spring, when most of the precipitation occurs, the weather is usually cool, although warm days are not uncommon. More than 200 clear days a year are

to be expected. The climate of the interior portion of the area, especially in the San Gabriel Valley, is somewhat warmer in summer than in the region between the low hills and the coast, but less fog and fewer strong winds occur. In spring and early summer light fogs frequently drift over the area in the evening, remaining until the middle of the next forenoon. Mild sea breezes frequently blow, especially in the southern part of the area, in the afternoons and evenings.

The Pasadena area is favored with a climate suited to crops that are very sensitive to frost. Certain parts of the area are especially adapted to such plants. The broad foothill belt lying along the base of the San Gabriel Mountains is a noted thermal belt, and there are smaller, similar areas at the base of the low sedimentary hills. While freezes are not unknown here, the topography and slope tend to prevent their occurrence. The settling of the colder air in the trough of the valley and the rise of the warmer air often prevents frosts in these thermal belts while they are damaging at lower elevations.

The latest killing frost in the spring recorded at Chino occurred on March 4, and the earliest in the fall on November 21. Parts of the area, however, are occasionally free from frost throughout the year, and in other places only a few frosts occur. Smudging, when necessary to prevent injury from frost, is practiced quite extensively. A number of seasons may pass without necessity for frost protection, but most of the growers of citrus fruits maintain equipment for smudging or orchard heating.

Hailstorms sometimes occur, but their effects are entirely local. The precipitation comes in the form of snow only on the higher mountains. Severe electrical storms are almost unknown.

The congenial climate attracts large numbers of tourists and health seekers to the region annually, and to it is in large measure attributable the rapid growth in population that has taken place.

A table showing the mean monthly, seasonal, and annual temperature and precipitation at Azusa and Chino is given on page 10. The weather conditions at Azusa, in the San Gabriel Valley, are typical of those of the citrus belt at the base of the San Gabriel Mountains, while those at Chino are characteristic of those prevailing farther out in the valley. While the elevation at Azusa is somewhat lower than at Chino, the former station shows a slightly higher temperature and a little heavier rainfall than does that at Chino. In the driest year recorded at Azusa the total precipitation amounted to 11.19 inches and in the wettest year 29.42 inches. The driest year on record at Chino had only 6.45 inches of rainfall, and the wettest year 27.32 inches.

Mean monthly, seasonal, and annual temperature and precipitation at Azusa and Chino.

Month.	Azusa (elevation, 540 feet).		Chino (elevation, 714 feet).	
	Temperature.	Rainfall.	Temperature.	Rainfall.
	°F.	Inches.	°F.	Inches.
December	53.9	1.41	52.2	1.90
January	53.0	3.91	51.1	3.96
February	53.7	3.25	53.4	2.59
Winter	53.5	8.57	52.2	8.45
March	56.3	4.28	55.3	3.74
April	60.1	1.00	60.8	.48
May	62.5	.93	65.4	.46
Spring	59.6	6.21	60.5	4.68
June	68.0	.15	72.2	.03
July	73.4	.00	77.7	.02
August	73.8	.08	76.4	.02
Summer	71.7	.23	75.4	.07
September	71.0	.28	72.3	.10
October	65.6	1.01	65.3	.79
November	59.0	1.56	57.0	1.33
Fall	65.2	2.85	64.9	2.22
Year	62.5	17.86	63.2	15.42

AGRICULTURE.

Agriculture in the Pasadena area, and in Southern California in general, began about 1773 with the planting of small gardens at the San Gabriel Mission, and the growing of wheat, corn, and barley on a small scale in the San Gabriel Valley. Because of the lack of knowledge concerning the weather conditions and proper methods of irrigation, crops at first were often failures, in many cases being drowned out if planted too near the stream channels or succumbing to drought if planted too far away.

Large tracts of land were granted to individuals by the Mexican Government. These large grants were used exclusively for grazing. Cattle raising, which was at first extensively carried on, was later superseded by the raising of sheep. The cattle, introduced from Mexico, were of poor quality. About 1850, when gold camps were established throughout the State, an impetus was given to agriculture. These camps furnished a market both for the grain that could be produced in the valleys and for the live stock that previously, because of the lack of transportation facilities and markets, was frequently slaughtered for the hides alone.

In the latter part of the eighteenth century it was found that European varieties of grapes could be grown with profit, and extensive plantings were made. Among the early varieties introduced were the Mission, Sonoma, Zinfandel, and Reisling. With the development of citrus-fruit growing and the extension of irrigation about 1870, viticulture began to wane, and at the present time it is an interest of minor importance.

The important agricultural interests of the Pasadena area at the present time are of several types. Truck crops are grown to some extent for home consumption, and the forage produced and part of the hay crop are used in the local agricultural industries, but in general the crops produced are grown almost exclusively for sale. It is evident that topographic position, location with reference to towns and markets, and the general soil and climatic conditions are the principal factors that affect the distribution of the crops. The principal crops, grown largely as a source of income, named in the order of their importance, are fruits, nuts, hay and forage crops, vegetable and truck crops, and cereals. Both citrus and deciduous fruits are grown. The former include mainly the orange and lemon, grapefruit and limes being grown to a small extent. The principal varieties of oranges grown are the Washington Navel and the Valencia. English walnuts are the chief nut crop. Of the deciduous fruits the peach and apricot are the most important. There is a small acreage in apples. A few vineyards, remnants of the early extensive plantings, are still productive.

Orange and lemon production has been developed in the high alluvial-fan belt on the southern slopes of the San Gabriel Mountains, between the Eaton and San Antonio Washes, mainly in the vicinity of Pomona, Claremont, Lordsburg, San Dimas, Glendora, Duarte, Azusa, and Covina. There are rather large orchards in the vicinity of Monrovia, south of Puente, and at San Marino, and scattered plantings have been made elsewhere throughout the area where conditions are favorable. Oranges are a much more important crop than lemons. The lemon groves are usually scattered throughout the citrus belt. There are, however, many large plantings of lemons, especially at Glendora and San Dimas and east of Covina. Large packing houses for handling the citrus fruits have been established in or near the larger areas of production.

In setting out the orchards, perhaps more attention has been given to selecting land favorably situated with reference to frost occurrence and facility of irrigation than to the character of the soil. Orchards in excellent condition exist upon soils ranging in texture from very light to heavy. The land selected for orange groves has in general included moderately uniform and even slopes

ranging from gentle to steep. Many of the more recent citrus plantings on the lighter textured and more stony and sandy soils have consisted of lemons. (See Plate I, figs. 1 and 2.) Transported soils of recent deposition, and those of the older valley-filling deposits, in which some of the transported material has undergone weathering, have been used almost exclusively for citrus planting. The residual soils, those derived through the disintegration from consolidated rocks in place, are used but little, except in a few instances where a water supply is available.

Much care is used by the citrus-fruit growers in selecting varieties, growing the nursery stock, budding, planting, and looking after the trees. The prevailing method of propagating citrus trees is budding upon seedlings of the sour orange, sweet orange, and pomelo. Trees are set out one or two years after budding. The square or rectangular system of planting, with the trees set 20 or 25 feet apart, is commonly followed at present, but plantings in the triangular, quincuncial, and hexagonal systems have been made. Clean cultivation is given throughout the spring and summer. Cover crops, consisting of vetch, alfalfa, clovers, and grasses, are seeded in the late summer, to remain until early spring, when they are plowed under. Considerable expenditures are made for stable manure and commercial fertilizers. Heavy applications of rotted barnyard manure are made by many growers in the spring where this material can be obtained from the cities at a reasonable price. The lighter textured soils, especially, require the adding of organic matter, which is supplied to a large extent in the form of manure. Commercial fertilizer, applied twice a year or oftener, in the spring or summer, usually consists of sodium nitrate, dried blood, and tankage. Fertilizers containing other ingredients are also used.

Much water is required by citrus orchards at all seasons of the year, and irrigation, according to reports of growers in various sections of the area, entails a cost ranging from $6 to $20 an acre. Irrigation is practiced by all the growers, six to eight applications being made in the course of the year. The rainfall is sufficient during the wet season, except when the precipitation is unusually light. The amount of water applied in irrigation varies greatly, depending largely upon the texture of the soil and the age of the grove.

Citrus trees are attacked by a number of serious diseases and insect pests that are kept in check only by constant vigilance. Chlorosis or mottled leaf, scale insects, red spider, mites, and fungous diseases are the principal enemies. The scale insects are combated by fumigating with hydrocyanic-acid gas under tents placed over the trees. This is usually done every other year, but in some

badly infected districts it is necessary to treat the trees annually. The cost of fumigating ranges from $25 to $100 an acre. Red spiders, mites, and fungus are controlled by spraying with lime-sulphur mixture. The application of powdered sulphur in the spring is also employed to combat these insect pests. Bordeaux mixture is also used to combat fungous diseases, of which the rot is the most common.

Frosts in December, January, and February sometimes cause injury to citrus trees, especially in the lower lying areas. Damaging frosts are not of yearly occurrence, but measures to insure protection have been taken, especially since the freeze of 1912–13, when much damage was done. The equipment chiefly used for smudging consists of pots filled with combustible oil, which are set between the rows of trees and lighted on nights when frosts seem likely to occur.

Citrus fruits ripen at all times of the year, mainly during the winter months, when deciduous trees are dormant. Lemons are picked when they have attained a satisfactory size, regardless of the stage of ripening. The Washington navel orange is harvested from December until April or May. The Valencia matures from May until August and seedlings also ripen in late spring and early summer. The citrus fruits mature later in this area than in the central and northern parts of the State.

The handling of citrus fruits is done by experienced workers. Picking and hauling are done by day labor, while packing is usually paid for by the box at good wages.[1] For the five-year period 1906–1911 an average yield of oranges of 157.6 packed boxes per acre, and of lemons of 196.2 packed boxes per acre, is reported by the Citrus Protective League of California, based on returns from many representative groves in the State. A large amount of capital is involved in citrus growing. Many of the operations connected with the industry are conducted cooperatively with great efficiency. The purchase of materials and of equipment for packing, and especially the marketing of the crops, are done through organizations, without which the present high state of development of the industry would be almost impossible.

The production of walnuts is a very important interest in the southern part of the Pasadena area, in the vicinity of Elmonte, Puente, Walnut, and Chino. The most extensive plantings are just to the east of Bassett and north of Puente, where walnut growing has reached its highest stage of development. The walnut groves have been planted on soils which, because of their position farther

[1] For cost of producing, handling, and marketing see Buls. 9 and 11, and paper entitled "Cost of Producing Oranges in California," issued by the Citrus Protective League of California.

out in the valley, are more subject to frosts and can not be utilized safely for citrus crops. The larger orchards are chiefly on fine sandy loams and loams derived from recent-alluvial deposits, but some groves in the vicinity of Garvey School are on soils derived from old valley fillings.

The principal varieties of walnuts are the Placentia, Eureka, Prolific, and Elmonte. As the trees reach a large size, the most common order of planting is the hexagonal arrangement, the trees being set 40 to 60 feet apart. Clean cultivation is the rule where the trees have attained sufficient size practically to cover the intervening ground, but cultivated crops or alfalfa are sometimes grown between the rows of young trees. Peach or apple trees are often planted as fillers in the nut orchards. All the groves are irrigated, two or three applications of water being given within the period from July to November. Little or no fertilizer is used.

Walnut trees bear annually. The average yield of 12-year-old trees is from 800 to 1,500 pounds of nuts per acre. The trees are but little affected by diseases, of which the blight is the most serious. Walnut production represents a very intensive type of agriculture. A conservative estimate of the annual acreage cost of growing walnuts has been placed at $50 by the Riverside experiment station. The groves give good returns on valuations of $500 to $600 an acre and some return a fair rate of interest on a $1,000 valuation.

The production of deciduous fruits is of minor importance in the agriculture of the area. The peach is the principal fruit of this class. There are also a few orchards of apricots and apples. These fruits are grown in permanent orchards and as fillers in walnut groves. The crops ripen at a later period than those of the same varieties grown in the warmer valleys in the central and northern parts of the State. Irrigation is necessary in the growing of all these fruits. The fruit is disposed of either as fresh fruit or to supply the canneries.

The largest plantings of deciduous fruits have been made in the districts south of Pomona and north of Chino, chiefly on the recent-alluvial soils that lie too far out in the valley to be used for citrus fruits. There are no large, continuous plantings, as in the case of the citrus fruits, peaches, apples, and apricots being grown in small to medium-sized orchards scattered through areas devoted to field crops. There are a few orchards of peaches and apricots in the vicinity of Devils Gate, in the northwestern part of the area. Apples are grown in plantings of 5 to 20 acres each, distributed through districts south of Elmonte and Chino. The apple orchards that have been set out are still young. The Yellow Bellflower is the leading variety of apple.

The Muir, Lovell, and Tuscan are the principal varieties of peaches. The trees usually begin to bear about 3 years after planting and live 15 to 20 years. The average yield of peaches, according to reports of growers, is 4 to 5 tons per acre. Little or no commercial fertilizer is used in the peach orchards, but barnyard manure is applied where easily obtainable. Clean culture is practiced in the mature orchards, but Egyptian corn and sugar beets are grown between the rows until the trees come into bearing.

European grapes were formerly grown more extensively than at present. Only a few of the early plantings remain. These are scattered over the area. The larger vineyards are in the vicinity of the wineries, which take the bulk of the production. Raisin grapes are grown only on a very small acreage. The Zinfandel and Berger are the chief varieties of grapes grown. A few plantings of the old Mission grapes, however, remain. The vineyards have, as a rule, been established upon soils of light, coarse texture, on which they seem to do best. Irrigation is generally practiced, but the vines yield without the application of water. Clean culture is practiced in the vineyards.

Grain growing is an interest of considerable importance, especially in the southern part of the area. In the early development of the agriculture grain growing was important in the valleys, but it is now largely confined to the rolling and hilly lands. The residual soils of the Puente and San Jose Hills are used extensively for grain growing. (Plate II, fig. 1.)

Barley and oats, cut for hay, are the principal grain crops. Wheat and Egyptian corn are grown to a small extent, the latter being confined to the western part of the area. The grain and grain-hay crops are dry farmed, irrigation being impracticable upon the hill lands devoted to them. The land is fallowed in alternate years, and fairly good yields of hay are obtainable even when the precipitation is below normal. Field observations indicate that the yields of grain hay average from 1½ to 2 tons per acre. The yields of thrashed grains are low, and as the crop brings a larger return if cut for hay, they are grown very largely for this purpose.

Alfalfa is grown most extensively in the vicinity of Elmonte and Chino, although small fields are found in practically all parts of the area. It is also seeded as a cover crop in citrus groves. Alfalfa is grown independently as an intensive crop in the lower lying situations well out in the valleys. Well-drained soils of medium to light texture seem to be best suited to the crop. While the first cutting of the season is produced without irrigation, except in unusually dry years, one application of water is made for each of the succeeding cuttings. Five to seven cuttings a year are obtained, each yielding

from three-fourths ton to 1½ tons. The life of an alfalfa field is 7 or 8 years, but after the fourth year the yields begin to decrease. Much of the alfalfa produced is sold as hay, but it is also fed to dairy cows and other live stock on the farms.

The good markets afforded by the large cities and towns which lie within and near the Pasadena area have encouraged the development of truck growing on a large scale. Truck is produced largely by foreigners, who rent the land. While various types of soil are used, the bulk of the production is grown upon the medium-textured, well-drained soils of the valley floor. Poorly drained soils of heavy texture and very high organic-matter content are used for the production of celery. Elmonte and San Gabriel are the principal centers of truck growing, but the industry is carried on near all the larger cities and towns. All varieties of truck and garden crops, including small fruits, berries, melons, and flowers, are grown.

The climate is favorable to the growing of some of those crops throughout the year, and a number of different crops are grown on the same land in a season. As a rule, the various truck crops are grown only in small fields. Change in crops aids in the control of pests and reduces the injury that might arise with uninterrupted growing of a single crop.

Hand labor is necessary to a very great extent in truck growing, but horses are used in cultivation where possible. Heavy applications of fertilizer, largely barnyard manure, are made regularly.

Sugar beets are grown more or less extensively in the vicinity of Chino, where a beet-sugar factory is operated. A small quantity of seed of fair quality is produced also. Beet growing is confined largely to rather poorly drained soils of medium to heavy texture, which are somewhat subject to the accumulation of alkali. Much of this land has been drained artificially. The soil is well suited to beet production. The seed is drilled in rows 16 to 18 inches apart. The plants are later thinned by hand to stand about 4 inches apart in the row and cultivated until they have made their growth. Usually two irrigations are necessary to insure an average yield of 10 tons per acre. A rotation with barley and alfalfa is generally followed, especially on land where the yields tend to decrease. The different crops are grown for a number of years before giving way to the one next in rotation. Barnyard manure is the only fertilizer used, and this is applied only in small quantities. Beets do fairly well on soils containing small quantities of alkali, but in the spots of considerable alkali concentration the yields are reduced. The sugar content of the beets ranges from 12 to 18 per cent.

Raising live stock is subordinate in the agriculture of the Pasadena area, where high land values prevail and where intensively grown crops that command good prices are produced. The live-stock

7868

FIG. 1.—YOUNG LEMON ORCHARD ON STONY SOILS OF THE HANFORD SERIES NEAR GLENDORA.

The larger stones have been removed from the surface.

7870

FIG. 2.—YOUNG LEMON ORCHARD ON HANFORD STONY SANDY LOAM NEAR AZUSA.

Stones removed from the surface have been piled on the left.

7337

FIG. 1.—GRAIN HAY NEAR WALNUT.

Alluvial soils of the Chino series in foreground occupying local stream valley. Residual soils of the Altamont series covering rolling hills in distance.

7533

FIG. 2.—POTATOES ON HANFORD SANDY LOAM NEAR ELMONTE.

industries include mainly dairying, the production of poultry and eggs, and the raising of cattle and hogs. Dairying is confined largely to the southern part of the area, where alfalfa is grown extensively, and to the vicinity of the larger towns and cities. Green forage is obtainable throughout the year, and only a few silos are in use. Dairy products, mainly milk, are disposed of more generally for city consumption than to creameries. The dairy animals are generally of the heavy milking types and of good breeding. The Holstein apparently predominates. Not all the ranches keep dairy cows, many of them depending upon the commercial dairy for home supplies.

Poultry raising and the production of eggs, frequently associated with the raising of hares, are carried on more or less extensively throughout the area, especially where the land is not well adapted to cultivation. These interests constitute the chief occupation of many farmers. Practically all the common breeds of poultry and hares are represented and the stock is in general purebred. Many of the large ranches in the area do not keep poultry. Excellent markets for poultry products and hares are afforded by the towns and large cities. Most of the feed used on the poultry farms is purchased.

Horses and mules are raised both for sale and for use on the farm. Except in the case of work stock, most of the horses and mules, as well as the young cattle and beef stock, are kept throughout the year upon the ranges, chiefly in the rough and rolling hill and mountain lands. The raising of cattle for slaughter is an unimportant interest. Hog raising has been taken up somewhat extensively on the stony, sandy wash lands, which are of little value for crop production. Most of the feed used consists of waste obtained from restaurants and hotels in the large cities. Only a few of the fruit growers keep hogs. Pork production promises to become of considerable importance, as a good market is always available.

Topographic position and the possibilities of irrigation control the distribution of crops to a greater extent than does soil adaptation, owing to the prominent place in the agriculture given to crops that are sensitive to frost and to the necessity for irrigation to insure good yields. Citrus fruits are grown upon soil types ranging in texture from light, porous sands to clay loams. They make their best development on medium and light textured soils of the broad alluvial fans sloping from the mountain to the trough of the valley. The distribution of crops is affected more by the broader and more general soil characteristics than by the soil type itself. Grain is grown chiefly where the soil, on account of shallowness, topography, and physical condition, is not suited to the production of crops that require

deeper soils and cultivation. Without irrigation, a difference in the appearance of the plants, in the yields, and in the cost of production is frequently noticeable upon different soil types.

On the more poorly drained soils, which are usually of heavy texture and in some cases subject to accumulations of alkali, sugar beets are the chief crop grown. Upon the better drained, generally lighter textured types of the valley floor, alfalfa, walnuts, peaches, apricots, and truck crops are the principal products. Where alfalfa is grown, dairying is carried on to some extent, largely on the recent-alluvial soils of the valley floor. The light, porous soils require more careful farming methods and heavier applications of organic matter and fertilizer, as well as more liberal irrigation, and neglected citrus orchards suffer much sooner than on the heavier types. Mistakes in selecting poorly adapted soils for these highly specialized fruit crops are often remedied somewhat by such means as applying large quantities of manure and fertilizer and plowing under cover crops. The rough and more rolling lands are used for grazing and the stony soils of recent-alluvial origin, in some cases subject to overflows, for hog raising. The methods of crop production are influenced but little by the soil type, the prevailing methods of farming for citrus fruits, deciduous fruits, walnuts, and other crops being followed throughout the area, with little variation.

The equipment used in fruit growing, trucking, and general farming is of the latest design. Some of the implements used have been devised to meet local requirements. The equipment used in gathering and packing citrus fruits is of the most improved type.

Large quantities of fertilizer are used annually in the Pasadena area. In Los Angeles County the expenditure in 1910 amounted to $669,152, more than was spent in any other county in the State except San Bernardino. By far the greater part of the fertilizers is used in citrus-fruit growing.

The laborers employed in the different lines of farming are for the most part skilled. Many foreigners are employed. Skilled labor is necessary in the handling of the citrus crops. The beet crop requires much hand labor. This is usually performed by Mexicans. Many Japanese, Chinese, and Mexicans work truck gardens. Skilled laborers in the citrus orchards are paid $2.50 to $5 a day, while $1.50 a day is the usual wage paid to the Mexican laborers in the beet fields.

The Pasadena area is one of highly specialized agriculture, and the size of the farms varies with the location, the character of the soil, the possibilities of irrigation, and the type of farming. According to the 1910 census, more than 30 per cent of the farms of Los Angeles County are under 10 acres in size and 77 per cent comprise less than 50 acres. The Pasadena area includes the most intensively

developed part of Los Angeles County, and the farms on the average are considerably smaller than in the county as a whole. The farms on the residual hill and mountain soils, which are largely unsuited to the more intensive crops, are larger than in the areas of transported or alluvial soils, which, because of the topography and the nature of the material, are much more valuable for the intensively grown crops. While the farms of the Pasadena area are usually small, in a few places large holdings still remain. Many of these large estates, however, are leased in small parcels. In general the farms close to the larger cities and towns are smaller in size than those at a greater distance. Citrus plantings are usually held in tracts of 5 or 10 acres, while the alfalfa farms contain 40 acres or more. The grain farms are larger than this, and grazing lands are held in large tracts.

Owners operate 73.4 per cent of the farms in Los Angeles County. Tenants work about 21 per cent and the remainder are operated by managers. Sixty-seven per cent of the tenanted farms in Los Angeles County are rented for cash.

The range in land values in the Pasadena area is very great, and valuations can be stated only in a general way. Land which in the raw state may have a value of only $200 or $500 an acre is usually held at a price many times greater when developed. Bearing orange orchards constitute the highest priced agricultural land; values range from $800 or $1,000 to $2,000 or more an acre, depending upon the age and condition of the trees, the soil, and the location. Land in walnut groves is ordinarily held at $500 or $600 an acre, but many groves are valued at $1,000 or more an acre. Developed orchards of deciduous fruits range in valuation from $300 to $500 or $600 an acre. The price of ordinary farm land, suitable for the production of alfalfa and sugar beets, ranges from $150 to $400 an acre, and that of grain land from $50 to $100 an acre.

Land near the larger cities and towns, even though used at present for orchard, general farming, or truck crops, usually is held at prices not warranted by its value for agriculture.

SOILS.

The soils of the Pasadena area have been derived from various kinds of rocks, including igneous and sedimentary formations, and unconsolidated deposits.

The igneous rocks occur in the San Gabriel Mountains, in the northern part of the area, and in the northern section of the San Rafael Hills, in the western part of the area. They consist almost entirely of quartz diorite, schist, and gneiss. Basic volcanic rocks occur here only to a very small extent and their area within the sur-

vey is inextensive. The principal outcrops in the San Gabriel Mountains occur at the mouth of San Dimas Canyon, north of San Dimas and east of Glendora. Other exposures occur in the small hill at San Dimas and at the eastern extremity of the San Jose Hills, west of Pomona.

The sedimentary rocks occur chiefly in the southern and eastern parts of the area. The San Rafael Hills are of sedimentary origin in the section south of Linda Vista, and the Puente and San Jose Hills consist chiefly of shales, sandstones, and conglomerates of Tertiary age. Much folding is noticeable in these stratified rocks. These hills contain some rocks similar to those characteristic of the San Gabriel Mountains, but outcrops of these formations are not common.[1]

The unconsolidated deposits occupy the valleys, which are structural basins resulting directly from crustal defarmation.[2] The deposits consist of alluvium laid down during at least two distinct periods of time. High benches formed of older material occur along the south slope of the San Gabriel Mountains from a point west of the Arroyo Seco to a point east of the San Dimas Canyon, and similar deposits occur extensively in the western part of the area.[3] The more recent alluvial deposit covers the larger part of the valleys and occurs at lower elevations than the older alluvium. It occupies broad, sloping belts at the base of the San Gabriel Mountains east of Eaton Wash and forms the soil of the valley troughs, including the chief agricultural lands of the area. All this valley-filling material, except that in small fans surrounding hills composed of sedimentary formations in the San Jose Valley, is derived from the granites and associated rocks of the San Gabriel Mountains. The deposit of alluvium is shallower and the material much coarser in the vicinity of the larger canyons and at the foot of the mountain slopes than farther out in the valley.

Between these several rock formations and the soils derived from them there is an obvious relationship. This is shown not only in the inherent characteristics of the soils, but also in the topography of the country which they occupy. The granitic rocks disintegrate readily, but they are comparatively hard, and erosion has left the granitic hills and mountains much more rugged and steep than the hills composed of the softer, sedimentary rock, mainly shale and conglomerate. Soils formed from granitic material are generally of lighter texture and more open structure than those derived from the decay of shale and sandstone. The residual granitic soils are, in this area at least, removed by wash more readily, and conse-

[1] See U. S. Geological Survey Water Supply Paper No. 219, p. 10.
[2] Ibid., pp. 14 and 15, also 31–33.
[3] Ibid., pp. 11 and 12.

quently are shallower than those derived in place from the sedimentary formations. Even in the case of the transported soils the kind of rocks from which the material comes may usually be determined, especially in the types of coarser texture.

According to their manner of accumulation, the soils of the Pasadena area are classified in three broad groups, namely, residual soils, soils derived from old valley-filling material, and soils derived from recent-alluvial material. The soils in each of these groups are further separated into series and the series into soil types, the type being the unit in constructing the map. The series includes types having common characteristics in color, depth, character of subsoil, origin, and mode of formation, and differing essentially only in texture.

The color, which is one of the important characters used to identify the soils, frequently shows considerable variation over small areas. Where differentiation between series is made largely upon color, arbitrary boundaries frequently are necessary where the soils of one series merge gradually with those of another, and some of the soils as mapped may include material of related series.

The residual soils have been derived from consolidated rocks through weathering and disintegration in place, without subsequent movement or admixture of the soil material except through local creep or erosion. The residual soils are confined very largely to the mountain and hill areas. Their value for agriculture is dependent almost entirely upon the depth of the soil material, the character of the topography, and the content of stones. In general, the topography ranges from rolling to steep and hilly, and the soils are shallow. Two series of residual soils are recognized in this survey, the Altamont and the Holland. Besides these series large areas of residual material have been mapped as Rough broken land and Rough stony land, nonagricultural types placed in the group of miscellaneous soils of which mention is made on a subsequent page.

The Altamont series includes types having medium to dark brown soils and light-brown or yellowish-brown subsoils. The subsoil may be absent, but where present it is usually compact and heavier than the surface soil. In many exposures the surface soil is seen to rest directly upon the underlying rock, the upper part of which is generally in a state of decay. The rocks from which these soils are directly derived are generally much folded formations of shale, sandstone, and conglomerate. The parent rocks and the resultant surface soils and subsoils frequently are calcareous. The topography ranges from rolling to steep and hilly, and the hills over which the series occurs are more or less dissected. Drainage is good to excessive. The slopes and hillsides, while steep, are usually smooth and to some extent cultivable. The soil material as a rule is moderately deep, and

becomes shallower with ascent of the hills until at the top of many there is little soil covering. The Altamont soils occur in the southern, central, and western parts of the area, and constitute the chief grain-producing lands. The loam, clay loam, and clay types are recognized in this survey.

The surface soils of the Holland series are typically brown. The subsoil, where developed, is brown, reddish brown or yellowish brown, and heavier and more compact than the soil. Both surface soil and subsoil usually contain coarse granitic material. The series is derived from granite and associated rocks. The topography is rough, steep, and hilly and drainage is excessive. Rock outcrop is abundant, and the surface is also broken by gullies and lesser erosions. The Holland series is of small extent in the Pasadena area. It occurs in the northeastern and northwestern parts. Because of the unfavorable topography and the shallow depth of soil the series is of little agricultural importance. Two types are mapped, the sandy loam and loam.

The soils derived from old valley-filling material have been formed from sedimentary deposits of an earlier period subsequently eroded and weathered, usually with the development of uniformly heavy or compact subsoils, and in some cases hardpans. These soils occupy remnants of old, elevated plains about the margins of the present valleys. They also occupy more extensive plains in the main valley. In the latter case, or where this old-alluvial deposit occurs as remnants surrounding residual knobs in the valley, the topography usually is smoothly sloping, but the marginal areas at the base of the San Gabriel Mountains are dissected and rough, and in places separated from lower lying, younger soils by an abrupt escarpment or by more gentle slopes which in the lower part frequently are covered with the more recent alluvial deposits.

The soils derived from old valley-filling deposits are classed in the Ramona, Placentia, and Antioch series. The materials forming the Ramona and Placentia soils come mainly from granite and associated rocks; that giving the Antioch series is derived typically from a variety of rocks, but in this area largely from sedimentary formations. The Ramona and Placentia series are differentiated largely on the basis of difference in color of the surface soil. Frequently the color changes very gradually, and arbitrary boundaries are sometimes necessary in mapping. The Ramona and Placentia series occur, closely associated, chiefly in the western and northwestern parts of the area, but also on the foot slopes of the San Gabriel Mountains and in the central part of the San Gabriel Valley. The Antioch series is unimportant and of small extent in the Pasadena area, but is extensively developed in the Riverside area to the east.

The surface soil of the types included in the Ramona series prevailingly is brown or reddish brown, and the subsoil lighter in color—brown, reddish brown, or brownish red—and heavier in texture than the surface soil. The subsoil is compacted or includes hardened layers that carry gravel and stones in varying proportions. In small areas there has been developed an iron-clay hardpan. In many deep cuts the subsoil and underlying strata show distinct stratification. The old, unconsolidated alluvial material giving rise to this series is very deep. The original deposits have been modified by weathering and in places by the addition of more recent alluvial material. The topography is in general that of a sloping plain, elevated above the more recent alluvial soils of the valley floor. The series occurs on several small, rough, and stony hills near the mountains at the north. Drainage ways here have been eroded deeply in places. The areas in most places are subject to erosion. With the exception of the stony loam type, the Ramona soils in this area can be irrigated. The Ramona stony loam, gravelly loam, loam, and clay loam are mapped in this survey.

The Placentia series includes types with pronounced reddish brown to red soils and red subsoils. When dry the surface soil is reddish brown, but when moist it is usually red. It is typically redder than the Ramona soils. The subsoil is heavier and more compact than the surface soil. Where exposed in cuts it shows an adobelike structure and frequently it includes strata of gravel and stones. In local areas an iron-clay hardpan is developed. If of sufficient extent the areas in which this occurs would be classed in a distinct series. The topography of the Placentia soils is that of a level to undulating plain, with steep to gentle marginal slopes, which are much dissected and gullied. The series in this area is of small extent. It occurs principally at the base of the foothills and represents remnants of the higher, old valley-plain surface. Only the loam member of the series is recognized in this survey.

The surface soils of the types included in the Antioch series are of brown to dark-brown color and the subsoils are grayish or yellowish. The texture of the surface soils is generally a little lighter than that of the subsoil, which usually is moderately compact and consists of stratified beds of sand, silt, and clay. Calcareous concretions occur in the subsoil. The topography of the country occupied by this series is that of a level to gently undulating plain, elevated somewhat above the adjoining soils of more recent origin. Drainage is moderately good. The Antioch series is represented in the Pasadena area by the silty clay loam type.

The soils derived from recent-alluvial valley filling consist of material transported by water at a comparatively recent date or, in some cases, still in process of accumulation. Unlike the soils from

old valley filling, they are not characterized by uniformly compact subsoils, and they have not undergone extensive weathering in place. The material has been transported from the mountain foot slopes and from the canyonlike stream courses, issuing into the valley on the alluvial-fan slopes, and finally reaching the valley trough. The slopes, which are usually steep at the mountain foot slopes, gradually diminish until the almost level valley floor is reached. The topography is that characteristic of alluvial fans. The drainage channels are not everywhere well established, especially farther out in the valley floor, and the soils are overflowed and eroded as a result of the heavy rains that occur periodically in the mountains and over the valleys.

The recent valley-filling alluvium gives rise to the Hanford, Tujunga, Chino, and Yolo series of soils. The Hanford, Tujunga, and Chino material is derived chiefly from granitic and associated rocks, while the Yolo soils consist largely of deposits derived from sedimentary rocks. The Hanford soils are the most widely distributed, extending from the mountains on the north far out into the valley and covering much of the river flood plain. The Yolo soils occur most extensively in the western and southern parts of the area. In addition to these soil types, areas of Riverwash, a nonagricultural type classed with the miscellaneous soils of the area and described in subsequent pages, are mapped.

The types included in the Hanford series have typically light grayish brown to brown soils and a subsoil differing little from the soil in color, though it may be a little lighter. The color of the types varies with the texture, the soils of light texture being light brown or light grayish brown, and those of heavier texture medium brown. In general, the soils differ little in texture throughout the 6-foot section, but in the stony types a gravelly or stony substratum underlies the surface soil. The subsoil usually has a more or less porous structure. The presence of micaceous material in conspicuous quantity is characteristic of the series. The material giving rise to the Hanford soils is of very recent deposition. The topography is that characteristic of sloping alluvial fans. The fans frequently occur high up on the foot slopes and frequently are steep. In the Pasadena area the Hanford series is represented by the stony sandy loam, gravelly sandy loam, sand, fine sand, sandy loam, fine sandy loam, and loam types.

The surface soils and subsoils of types of the Tujunga series are gray or light brownish gray, the subsoils often being of somewhat lighter shade than the soil. The grayish color is due very largely to the presence of coarser soil material and stone; the finer soil material is more grayish brown. The texture generally differs little within the 6-foot section, and the material is loose and open in

structure. The Tujunga soils consist of both alluvial-fan and river flood plain deposits. Where they occur on alluvial fans they usually occupy the highest and most recently formed parts, giving way gradually to the Hanford soils in the lower parts. The topography of the Tujunga series varies from level to sloping. The Tujunga stony sand represents the series in this area. In general, it resembles the lighter types of the Hanford series, but has a more pronounced grayish color.

The surface soils of the Chino series typically are dark gray to black, while the subsoils are gray to dark gray. The texture of the surface soil usually is lighter than that of the subsoil, which is generally water-logged. The high mica content of the Chino soils indicates that they are largely of granitic origin. The subsoils, however, contain considerable calcareous material. The topography of the Chino series is that of a gently sloping plain in which some small, shallow depressions occur. The position is somewhat lower than that of the Hanford series and drainage usually is rather poor. The Chino series is not extensive in this area. It is mapped in the southern and southeastern parts, and is represented by the loam and silty clay loam types.

The types of the Yolo series have brown to dark-brown surface soils and slightly lighter brown subsoils. The latter are usually not distinctly heavier or more compact than the surface soils, and in many places they are slightly lighter in texture and more friable. As mapped in this area, the Yolo soils are prevailingly dark, resembling the dark-gray soils of the related Dublin series, which is not recognized in this survey. The greater part of the material giving rise to the Yolo series is of recent deposition, but some of it approaches in age and degree of weathering the older valley filling. The topography is generally that of gently sloping alluvial fans which decrease in grade with distance from the hills. The surface is in general smooth and well suited to irrigation. In the Pasadena area the Yolo loam and clay loam types are mapped.

In addition to the 23 types included in the nine series recognized, three miscellaneous classifications are recognized in mapping the soils of the Pasadena area. Rough broken land includes extensive areas of mountainous and hilly lands, comprising partly residual and partly valley-filling soils, where the topography is too rough to permit cultivation. Rough stony land comprises areas in which the land is not only rough and broken but is so stony as to be nonarable. Riverwash comprises the coarse-textured deposits along the larger streams. It is subject to frequent overflow and is in general nonagricultural.

In the following pages of this report the various soils are described in detail and their relation to agriculture is briefly discussed. The

distribution of the soils is shown on the map accompanying the report. The following table gives the name and actual and relative extent of each soil type mapped:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Rough broken land	44,288	16.3	Hanford stony sandy loam	7,168	2.6
Hanford fine sandy loam	33,216	12.3	Yolo loam	6,848	2.5
Hanford gravelly sandy loam	28,160	10.4	Hanford loam	6,400	2.4
Altamont clay	19,840	8.7	Hanford fine sand	6,208	2.3
Dark-colored phase	3,712		Chino loam	4,288	1.6
Ramona loam	20,096	7.4	Hanford sand	3,840	1.4
Rough stony land	13,696	5.1	Altamont loam	3,200	1.2
Hanford sandy loam	12,416	4.6	Holland loam	3,200	1.2
Chino silty clay loam	8,384	4.4	Altamont clay loam	3,136	1.2
Adobe phase	3,584		Placentia loam	1,920	.7
Yolo clay loam	7,872	4.3	Ramona stony loam	1,088	.4
Heavy phase	3,712		Holland sandy loam	576	.2
Tujunga stony sand	5,888	2.9	Ramona clay loam	576	.2
Overflow phase	1,984		Antioch silty clay loam	512	.2
Riverwash	7,616	2.8			
Ramona gravelly loam	7,296	2.7	Total	270,720	

ALTAMONT LOAM.

The Altamont loam consists of a medium-brown, somewhat gritty loam, 10 to 15 inches in depth, generally underlain by a lighter brown or yellowish-brown loam or clay loam subsoil which extends to depths ranging from 26 to 60 inches. A distinct subsoil, however, is not always present; the rock from which the soil is derived directly underlies the surface soil in places and frequently outcrops. The type in some places, particularly in the areas at or near the summits of the low hills, carries some gravel and is lighter in texture and shallower than typical. At the base of the hills the soil is generally slightly heavier in texture and deeper than typical.

The surface soil usually has a small or moderate content of organic matter and it generally is friable. The soil is fairly retentive of moisture in the deeper areas, but where shallow it does not hold moisture well. In places the type, particularly in the subsoil, contains a small quantity of calcareous material.

The Altamont loam occurs in several fairly large areas and many small ones. The largest bodies occur south of Ramona and west of Pasadena. Areas of various sizes are scattered throughout the hills of sedimentary rocks in the southern part of the survey from Arroyo Seco to a point south of Pomona.

The topography is characteristic of the series, being rolling or hilly and not adapted to irrigation. Drainage is well established

and the type is a little more subject to erosion than the heavier members of the series.

The Altamont loam is the result of the breaking down of rocks consisting mainly of sandstones and conglomerates, but to some extent of shale. Where shale has entered into the formation of the soil the texture is heavier than typical. This type occurs at higher elevations than do the other Altamont soils.

The Altamont loam is cultivated less extensively than the other types of the series. It is used largely as pasture for horses and cattle. Grain is the chief crop grown. Because of the somewhat light texture and, in many cases, the low water-holding capacity of the soil, the yields of grain are not heavy.

As the type is not irrigable its agricultural value is low. Much of it, however, lies within or near large cities and is used for building sites.

ALTAMONT CLAY LOAM.

The surface soil of the Altamont clay loam consists of a brown to grayish-brown, rather silty clay loam, ranging from 10 to 16 inches in depth. This is underlain by a yellowish-brown silty clay loam or clay, which extends to the underlying bedrock. The bedrock usually is encountered at a depth of 20 to 24 inches, but in places it is not reached above a depth of 5 feet; on the other hand, the surface soil in places is directly underlain by the bedrock, and the latter occasionally outcrops.

There is more or less uniformity in texture throughout the greater part of the type, although some lighter or heavier soil is included in places. Both the surface soil and subsoil have a compact, heavy structure. The soil is sticky when moist; when dry it becomes hard and cracks somewhat. With cultivation or shallow plowing for a number of years a plowsole develops. The soil has only a small or moderate content of organic matter. Its water-holding capacity is greater than that of the Altamont loam.

The largest areas of the Altamont clay loam occur south of Walnut, south of Chino, and southwest of Puente. Smaller bodies are scattered through the hills in the southern part of the survey, and the type occurs in a number of outlying areas, surrounded by soils derived from old valley-filling material. Several such areas, on small knobs showing exposures of the underlying rock, occur at Pasadena and Alhambra.

The surface of the type is generally rolling and hilly and not favorable to irrigation. The slopes and hillsides are generally smooth, but steep. The rock outcrop consists of soft shale or sandstone, and weathers rapidly. In general, the surface drainage is excessive, owing to the steep topography, and as a result of the rapid run-off the surface is somewhat gullied and dissected.

The Altamont clay loam is used either for the growing of grain for hay or for pasturing horses and cattle. That part of the type within the corporate limits of the city of Los Angeles is not used for agriculture.

Because of its heavier texture the type is better adapted to the growing of grain than the Altamont loam. Barley and oats are the chief crops grown. The yield of hay probably averages about 2 tons per acre, but varies greatly with the rainfall. Summer fallowing in alternate years is a good practice in farming this type.

Much of the land of this type has a value not based on its agricultural possibilities. Its agricultural value ranges from $40 to $100 an acre.

This soil is of heavy texture and requires careful handling. It probably would prove advantageous gradually to deepen the plowing.

ALTAMONT CLAY.

Typically, the Altamont clay consists of a dark-brown or dark grayish brown, sticky clay, underlain by a heavy clay subsoil which is somewhat lighter brown than the surface soil. The depth of the surface soil ranges from 8 to 12 inches; the subsoil ordinarily extends to depths of about 24 to 36 inches, and in the deepest areas it may continue to a depth of 4 feet before the underlying bedrock is reached. The subsoil is not everywhere present, the surface soil in places resting upon the underlying rock at depths ranging from a few inches to 10 or 12 inches. The underlying soil-giving formation is of sedimentary origin. It generally is a soft, brown shale. Some impure limestone may be present, and calcareous material is common in the subsoil.

The soil and subsoil of this type are very compact. The surface soil becomes very hard and cracks upon drying. It has a moderate content of organic matter, and the type except where shallow is retentive of moisture.

As is the case with the other members of the series, the Altamont clay varies slightly in texture, color, and depth with elevation. The material is somewhat coarser in texture and lighter in color near the tops of the low hills than at the base, where it is deeper and cracks more readily. At the base of many of the hills the material is a heavy clay, while near the summits it is a clay loam.

The Altamont clay is the most extensive and important type of the series. It is distributed throughout the southern part of the area. The hills occupied by the type are low and rounded, and while the slopes frequently are rather steep, they usually are smooth enough for plowing and harvesting grain. Irrigation would be difficult, and is not practiced. Surface drainage is excessive.

The Altamont clay, like the clay loam, has been formed largely through the weathering of shales in place.

This is the principal grain and grain-hay soil of the area and apparently is best adapted to the growing of these crops and to grazing. The areas of steeper topography and those somewhat remote from towns are used for pasturing horses and cattle. Some wheat is grown for the grain, yielding about 25 bushels per acre, but most of the grain seeded, mainly barley and oats, is cut for hay. The average yield is about 2 tons per acre. The yield of grain is largely dependent upon the seasonal precipitation. Plate II, fig. 1, shows a crop of grain hay on this type of soil near Walnut.

The common practice of summer fallowing in alternate years is followed on this type. The land is plowed one season and sown to grain the next. Practically no fertilizer is used.

Altamont clay, dark-colored phase.—The dark-colored phase of the Altamont clay consists of a dark brownish gray, light clay, 16 to 20 inches in depth, typically overlying a heavy clay subsoil, which ranges in color from brown or grayish brown to gray, and which extends to a depth of 4 to 6 feet or more. The subsoil is absent in places, the bedrock being covered only by a shallow surface soil. Both the surface soil and subsoil are compact. The material is sticky when wet and checks when dry. Very frequently calcareous material is encountered. In general, the surface soil has a good organic-matter content.

In several included areas the surface soil is a dark-gray to black, heavy clay of adobe structure, which cracks very deeply when dry and uncultivated, often exposing the roots of plants. The soil is, however, high in organic matter and retentive of moisture, and a fair surface mulch can be maintained by cultivation. This adobe variation occurs in several fairly extensive areas, the largest of which is west of Spadra. Smaller developments are encountered southwest of Ramona.

The Altamont clay, dark-colored phase, is not extensive. The principal areas occur south and west of Ramona. Several small bodies are encountered south of San Jose and north of Walnut.

The surface of the phase is rolling and hilly, and not well suited to irrigation. The hills, however, while steep generally are moderately free from gullies and can be cultivated. Surface drainage is excessive, but the phase is retentive of moisture and the soil is wet in spots where an underlying impervious layer entirely prevents the escape of moisture.

Where the land is not cultivated bur clover is a common growth on this soil. Grain and grain hay are the chief crops produced. Yields of hay possibly are a little higher than on the typical Alta-

mont clay. Fallowing in alternate years is highly advantageous in farming this soil. No fertilizers are used.

Land values on this phase vary widely. Areas near the larger towns and cities have a speculative value, mainly for residence sites. The value of the land for agriculture is about the same as that of the typical Altamont clay.

HOLLAND SANDY LOAM.

The Holland sandy loam consists of a brown, rather coarse textured sandy loam, 8 to 20 inches in depth. When a subsoil is present it consists of a lighter brown or reddish-brown sandy loam or loam which usually extends to a depth of less than 6 feet. Beneath this is the bedrock, consisting of granite, gneiss, or associated rocks, from which the soil has been derived. Where the subsoil is absent this bedrock directly underlies a shallow mantle of soil, and in places it is exposed as rock outcrop. The material usually is micaceous.

The type is friable in structure, both surface soil and subsoil containing considerable grit. The subsoil, however, especially where it gives way to the rotten granite beneath, is much more compact and retentive of moisture than the surface soil. The type is not high in organic matter.

The Holland sandy loam occurs in one rather large area in the foothills near Lordsburg, while several smaller areas were mapped near Pomona and west of Pasadena. The surface ranges from rolling to rough and hilly. The land is irrigated in places, but the greater part of the type is too steep for irrigation. The surface is dissected by numerous gullies and ravines, and is well drained.

Small trees and brush, with a sparse growth of grass, constitute the chief vegetation on the type. Several small plantings of grapes have been made and some grain is grown, but the type is used for agriculture to only a very small extent. It furnishes rather scant grazing for horses. The value of this soil for agriculture is low.

HOLLAND LOAM.

The surface soil of the Holland loam is a brown, gritty loam, ranging from 10 to 20 inches in depth. The subsoil where present is a brown or reddish-brown, gritty loam, which usually gives way to the disintegrated granite rock that underlies the type at a depth of less than 6 feet. The color of both surface soil and subsoil is quite uniform from place to place, but in local areas the former is reddish brown or yellowish brown. The depth of the soil covering over the underlying rock is greater in the ravines and gullies than on the ridges, where the bedrock frequently outcrops. The organic-matter content of the type usually is low, and the micaceous, friable material is not very retentive of moisture.

As mapped the Holland loam includes a variation in which the soil differs from the prevailing type chiefly in origin, having been derived largely from volcanic rock. Several areas of this soil occur just west of Pomona. If more extensive it would probably be classed with a distinct series.

A large part of the hill and mountain land occupied by the Holland loam is too steep and rough to be of value for agriculture and is included in soil mapping with Rough broken land and Rough stony land. The most important areas of the type occur in the vicinity of Linda Vista and Montrose. It also covers several knobs, surrounded by soils from transported material, in La Canada Valley and at Pasadena. Small, unimportant areas occur in the foothills north of Claremont.

The surface is rough and dissected, but in places the type can be irrigated. Drainage is everywhere well established.

Small trees and brush constitute the chief vegetation. The type is little used for agriculture.

The value of this type in the western part of the area is high, the land where not too rough being in suburban lots. Land values on the type in other parts of the area are low.

RAMONA STONY LOAM.

The Ramona stony loam, which is indicated on the soil map by stone symbols in the color used for the Ramona gravelly loam, consists of a brown loam of light to medium texture, 18 to 24 inches in depth. Stones ranging in size from small to very large are commonly encountered on the surface. A subsoil of light-brown to reddish-brown stony sandy loam or stony loam underlies the surface soil, usually extending to a depth of more than 6 feet. In many places some of the stones it carries are in a partially weathered state. In general it is more or less compact, although moderately penetrable by the roots of plants. The surface soil is gritty and friable, and of porous structure. It has a moderate content of organic matter, however, and retains moisture fairly well. The type as mapped includes areas in which the soil is shallower than typical and approaches in texture a stony sandy loam.

The Ramona stony loam is of small extent. It occurs mainly in elongated bodies along the Arroyo Seco near Devils Gate and west of the Eaton Wash. Smaller bodies of irregular outline are mapped at Altadena and Monrovia and in the vicinity of Azusa.

The Ramona stony loam varies widely in topography. Along the Arroyo Seco and Eaton Wash it has a moderately smooth surface and a gentle slope, while on the mountain foot slopes in the northern part of the area it has a generally rough and hilly surface, with

steep slopes. Because of its high, sloping position, rough topography, and numerous large surface stones it is difficult to irrigate. Good to excessive drainage prevails throughout the type.

The Ramona stony loam is unimportant agriculturally. Owing to its stony surface, steep topography, and unfavorable location it is farmed to only a small extent.

The value of the land varies greatly, depending largely on the location. The greater part of the type is within the limits of cities and towns and is valued as residential property.

RAMONA GRAVELLY LOAM.

The Ramona gravelly loam consists of a brown, friable gravelly loam, ranging from 18 to 24 inches in depth and underlain by a light-brown or reddish-brown gravelly loam, stony loam, or sandy loam, which extends to a depth of more than 6 feet. The gravel content in the surface soil varies greatly. The gravel usually is subangular to rounded and ranges in size from small to large. The subsoil, which is usually very compact, carries a large proportion of gravel fragments and stones, some of which are in a state of decay. Mica is noticeable in the surface soil in places, frequently in large quantity, especially where weathering has taken place. The organic-matter content of the soil is only moderate. The soil is fairly retentive of moisture. The principal variation in this type is in texture; locally it may be as light as a gravelly sandy loam.

The most important occurrences of the Ramona gravelly loam are in the western part of the survey. A large part of the city of Pasadena is situated on this type. Numerous elongated, irregular areas roughly parallel some of the drainage channels near Alhambra and San Gabriel. Small bodies occur west of Sierra Madre, just east of Covina, in the extreme northeastern part of the area and just west of Eaton Wash. The surface is in general that of a gently sloping plain, but shallow depressions and terraces of minor importance occur. Just east of the Arroyo Seco the type occupies terraces of considerable extent. It generally lies higher than the loam type of the series.

The Ramona gravelly loam is everywhere well drained. In many places it is dissected by deep channels, as to the east of Alhambra. Practically all the type, however, is irrigable.

The parent material was deposited as heavy gravel wash by the streams issuing from the mountains to the north. In several places, noticeably at North Pasadena and at the Raymond Hotel in South Pasadena, several small knobs of residual material outcrop through the deposit. Some wash from the more recent alluvial soils has been

added to the material where the type comes in contact with soils from the younger alluvium. This is especially noticeable at Altadena, where the more recent soils lie at a higher elevation.

The Ramona gravelly loam is of minor importance in the general agriculture of the area. The greater part of the type lies within the limits of cities and towns in the western part of the survey. In South Pasadena and Alhambra and north of San Gabriel citrus fruits are grown, and they constitute the only crops produced commercially.

Land prices on this type vary greatly, and are not based on the agricultural worth of the soil.

RAMONA LOAM.

The surface soil of the Ramona loam typically is a brown to reddish-brown, gritty loam of medium texture, varying from 12 to 20 inches in depth. The subsoil, which extends to a depth of more than 6 feet, is a lighter brown or reddish-brown, compact loam or clay loam, carrying gravel and stones and showing some weathering and stratification. An iron-clay hardpan is exposed in places in cuts. It is encountered usually at a depth of 50 inches or more but is of local occurrence. The surface soil varies in texture from a heavy fine sandy loam to a heavy loam. It is somewhat deeper in the occasional shallow depressions. In places it contains gravel, especially where the type comes in contact with gravelly soils.

The surface soil contains mica in places; the subsoil is generally still more micaceous. The surface soil is only moderately well supplied with organic matter. Where cultivated it retains moisture very well, but in untilled areas it dries out rapidly and bakes. The compact subsoil frequently retards the development of roots, especially where the land is not irrigated.

Because of its large extent and its agricultural value the Ramona loam is one of the most important soils in the area. It occurs in both large and small areas, mainly in the western and southwestern parts of the survey, but also along the northern foothills and out in the valley. Where the type occurs on the mountain foot slopes the higher parts commonly are covered with a shallow deposit of the more recent alluvial soil material. Small, unimportant areas of the type occur in the San Jose Valley as remnants of a formerly extensive body of valley filling.

The surface usually is smooth and undulating, with a gentle slope. The topography is favorable to cultivation and irrigation. In the vicinity of San Dimas, especially along Walnut Creek, the type resembles old terraces. It usually lies at a higher level than adjacent

soils of more recent origin, and although in many places it merges gradually into other types it is often separated by an escarpment a few hundred feet in height. The highest escarpments occur near the foothills, where streams issuing from the mountains have deeply dissected the high-lying deposits that give rise to this type. The escarpments generally are very steep and rough and are mapped as Rough broken land where of sufficient extent.

Drainage over the Ramona loam is well established. In general, the type is dissected by drainage ways that are well defined and frequently deep, but in places there are low depressions that contain water at times.

The greater part of the Ramona loam is farmed. The type within and near some of the cities and towns is used largely for the production of fruits and of vegetables on a noncommercial scale. The type is most extensively used for the growing of citrus fruits, to which the soil apparently is well adapted. Both oranges and lemons are grown. Citrus production is chiefly centered about San Dimas, although there are many orange groves in the western, northern, and southern areas of the type. The varieties of oranges commonly grown in this region are produced, and average yields are obtained. It is probable that less fertilization and irrigation are necessary on this type of soil than on soils of lighter texture. Grain is grown most extensively on the type in the southwestern part of the area, near Los Angeles and Pasadena, where the land is too valuable to be put in long-lived crops, and is seeded to grain merely in order to keep it occupied until used for building sites. In several areas along Walnut Creek, southeast of Covina, grain is grown for hay. The soil is fallowed in alternate years and no fertilizer is used. The yields obtained are about the average for the area. Grain land is not irrigated. English walnuts are grown in the vicinity of Garvey School. The ordinary methods of culture and irrigation are followed and the yields are fair. Grapes for wine are grown to a small extent south of Bassett. A small part of this type, including areas between the residual hills southwest of Shorb, is devoted to grazing. Horses, mules, and cattle are pastured.

Land values on the Ramona loam vary widely, and can be given only in a general way. In the vicinity of the larger cities the type has a value determined by its location. Land in orange orchards is held at $2,000 to $3,000 an acre. Walnut groves are held at $1,000 or more an acre. The price of land planted to grapes ranges from about $300 to $600 an acre. The selling price of unused land, suitable for grain growing or pasture, ranges from $50 to several hundred dollars an acre, depending largely upon the location.

RAMONA CLAY LOAM.

The Ramona clay loam consists of a brown to reddish-brown, compact clay loam, 18 to 24 inches in depth, underlain by a compact, heavy clay loam, sometimes carrying gravel, which extends to a depth of more than 6 feet. Both the surface soil and subsoil usually are moderately high in silt and contain finely divided mica. The surface soil has a moderate content of organic matter, more than is contained in the loam of this series. There is little variation throughout the type. Near the gravelly types the soil in places carries gravel on the surface, and where it approaches the lighter textured types of the Hanford series it is somewhat coarser than typical.

The Ramona clay loam occurs in two areas at Lordsburg. The topography is that of a level to gently sloping plain, which is easily cultivated and irrigated. Most of the type is well drained, but a high water table is present in part of the area lying near the Pacific Electric Railway. The condition of several walnut groves here indicates that artificial drainage would be beneficial.

Citrus fruits, mainly oranges, are practically the only crops grown on the Ramona clay loam. The soil apparently is well suited to citrus crops, and yields probably are slightly above the average for the area. The methods of handling the soil, caring for the orchards, and marketing the crops do not differ greatly from those followed on the Ramona loam. The soil is somewhat stickier and requires more care in plowing and in cultivation, but it is more retentive of moisture and requires less irrigation water than the loam.

The price of land of this type in bearing citrus groves is about the same as that of the Ramona loam, ranging from $1,000 to $3,000 an acre. A part of the type has a high value, owing to its location within or near the town of Lordsburg.

PLACENTIA LOAM.

The Placentia loam consists of a light-reddish or pronounced reddish brown to red, compact loam, 12 to 18 inches in depth, underlain by a red, compact clay loam of adobelike structure. The surface soil is sticky when wet and very hard when dry. It has a moderate content of organic matter and retains moisture well. The heavy, compact subsoil frequently carries gravel and stones. A hardpan stratum is encountered in places, although this is not characteristic of the series. Where this occurs it usually is encountered at a depth of 3 feet or more. The subsoil where the hardpan is not developed becomes softened after cultivation and irrigation for a period of years, making it favorable to the development of roots.

The Placentia loam is largely confined to the vicinity of the foot slopes of the San Gabriel Mountains. The type occurs in numerous

small to fairly large bodies between Montrose and the San Antonio Wash. An area of considerable size occurs just northwest of San Dimas, and other important bodies are encountered in the foothills east of the San Dimas Wash.

The topography of this type is similar to that of the Ramona loam. The surface of the areas farther out in the valley usually is more or less undulating, while the areas in the foothills have a rougher surface, with occasional steep slopes. The Placentia loam usually lies somewhat higher than the adjoining recent-alluvial soils, the boundary frequently being marked by steep and eroded slopes. Drainage is well established over the type. The areas lying farther from the mountains can be irrigated without great difficulty.

The chief use of the Placentia loam in the larger areas is for the production of citrus fruits, while grain is grown where the elevation is too great for irrigation. The citrus groves apparently produce fair yields and are moderately well suited to the soil and other conditions. Cover crops and manure are plowed under to increase the organic-matter content and commercial fertilizers are applied to the land in bearing groves.

The price of land of the Placentia loam varies widely. Land in citrus orchards ranges from $1,000 an acre upward, depending mainly on the age of the trees. Unused land is held at $50 to $300 or more an acre.

The Placentia loam, owing to its compact, sticky nature, requires care in handling. The soil in places is very low in organic matter, and its physical condition is materially improved by the addition of manure and the growing and plowing under of green-manure crops.

ANTIOCH SILTY CLAY LOAM.

The surface soil of the Antioch silty clay loam is a brown to dark-brown, more or less friable silty clay loam, 18 to 24 inches in depth. The subsoil consists of a grayish or yellowish, more or less compact mass of silt and clay, extending to depths of more than 6 feet. It shows stratification, and frequently is mottled. Much of the material of this type is calcareous, and small calcareous concretions frequently are encountered in the subsoil. The surface soil carries a fair content of organic matter, and in the slight depressions occurring over the type it is heavier in texture and darker in color than typical.

The Antioch silty clay loam is of very small extent in this area. It occurs in the southeastern corner, adjoining extensive areas of the type in the Riverside area to the east.

This type is slightly elevated above the recent-alluvial soils. The surface is generally level, but contains numerous slight depressions.

Irrigation is easily accomplished and cultivation can be carried on without difficulty. Drainage is fairly well established, although in places the type has a high water table. Spots of alkali occur, but these are unimportant except locally.

Grain hay is the chief crop grown on this type. The yields are fairly good.

Unused land of this type ranges in value from $50 to $150 an acre.

HANFORD STONY SANDY LOAM.

The Hanford stony sandy loam is indicated on the soil map by stone symbols in the color used for the Hanford sandy loam. The type is similar to the Hanford gravelly sandy loam in texture of the finer material, differing chiefly in the quantity of large and small stones scattered over the surface and throughout the soil mass. In the higher lying areas the soil material is coarser in texture and shallower than in the case of the typical Hanford gravelly sandy loam.

The Hanford stony sandy loam occurs in several large bodies near the San Antonio Wash and in a number of smaller areas at the base of the mountains along the northern boundary of the area. The surface in many places is rougher than that of the Hanford gravelly sandy loam, and cultivation and irrigation are consequently more difficult.

The type is not farmed so extensively as the Hanford gravelly sandy loam. Plantings of oranges and lemons have been made between Monrovia and the eastern boundary of the area, but many of the groves are not yet bearing. That part of the type northwest of Montrose is largely unused at present.

The price of this type is lower than that of the gravelly sandy loam. It ranges from about $100 an acre for unused land to $800 or more an acre for land in bearing orchards. The cost of removing the stones affects the value of the land.

HANFORD GRAVELLY SANDY LOAM.

The Hanford gravelly sandy loam consists of a light-brown or brown, porous gravelly sandy loam, 18 to 30 inches in depth. This grades into more porous material which extends to great depths. Frequently there is little variation in the material throughout the 6-foot section. The soil carries gravel in varying quantities. The content is greatest on the higher slopes; it is everywhere sufficient to make the soil friable and open and favorable to the development of plant roots. The organic-matter content of the type is lower than that of the fine sandy loam. Considerable mica usually is present in the material.

In the areas of the Hanford gravelly sandy loam nearer the mountains, the texture is somewhat lighter, and gravel, which is almost entirely angular, is present in larger quantities than farther out in the valley, where the particles are more rounded and waterworn. The type nearer the trough of the valley is more uniform than at the higher elevations, where more gravel and stone fragments occur in the subsoil and where the surface soil is shallower. The boundaries separating this type from the Hanford stony sandy loam are in places drawn somewhat arbitrarily, and within the gradational zone the surface is sometimes stony.

The Hanford gravelly sandy loam occurs extensively in the northwestern and northern parts of the area, from Montrose, in La Canada Valley, to the eastern boundary of the survey. The areas of the type are of irregular outline, frequently surrounding bodies of other soils. The surface varies from almost level to gently sloping, with some steep slopes. The type, as a whole, is well drained. Small, shallow drainage ways carry the run-off, and the type is sometimes subjected to considerable washing in periods of heavy rainfall, owing to inadequacy of drainage channels. Cultivation and irrigation are in general not difficult on this type.

The Hanford gravelly sandy loam is of considerable importance in the agriculture of the area. The production of citrus fruits, largely oranges, which constitutes by far its most important use, is most extensively developed in the vicinity of Pomona, Lordsburg, Covina, Glendora, and Monrovia. Yields apparently are equal to or above the average for the area. The Hanford gravelly sandy loam probably requires more liberal irrigation than do the heavier types of the series, and it is necessary to incorporate more organic matter in the soil by applying manure and plowing under cover crops. Commercial fertilizers, consisting chiefly of nitrate of soda, dried blood, and tankage, are used. The applications made are similar to those in common use throughout the area. Grapes are the most important crop grown on this type west of Eaton Wash, the vineyards now bearing fruit being the remnants of former extensive plantings. There are a few orchards of deciduous fruits on this type, and truck is grown to some extent near the larger cities and towns.

Land prices over the Hanford gravelly sandy loam are high. A part of the type is within the limits of towns and cities. Land in orange groves is held at about the same prices as the Hanford fine sandy loam, ranging from $1,500 to $3,000 an acre.

In farming the Hanford gravelly sandy loam it is necessary to maintain the organic-matter content and to adopt measures to prevent leaching. Unless care is used the soil is likely to wash badly, especially on slopes.

HANFORD SAND.

The Hanford sand in its typical development consists of a light-brown to light grayish brown micaceous sand of medium texture, extending with little change to a depth of 6 feet or more. Gravel and stone fragments are encountered over the surface along some of the drainage ways and elsewhere in spots. Where it occurs as an overflow plain along the stream channels the soil is of coarser texture than typical.

The Hanford sand retains moisture well, considering its low organic-matter content, but considerable water is necessary for the production of crops, owing to the open, porous structure of the soil.

A large area of typical Hanford sand occurs at Baldwin Park. Several smaller areas are mapped east of Monrovia and along the San Gabriel River and Lexington Wash.

This type is well drained except where it occurs as an overflow plain. The surface is level or gently sloping and is favorable to irrigation.

Little agricultural use has been made of this type except near Vineland, where several citrus orchards have recently been set out. The yields probably are below the average for the area.

Liberal irrigation and heavy fertilization are necessary in farming this type. It requires the addition of large quantities of organic matter.

The price of the Hanford sand ranges from a few dollars an acre for overflowed land to $800 or $1,000 or more an acre for land in bearing orchards.

HANFORD FINE SAND.

Typically the Hanford fine sand to a depth of 6 feet or more consists of a micaceous fine sand, grayish brown when moist and grayish when dry. The organic-matter content usually is low, but the type retains moisture moderately well, considering its porous nature.

The Hanford fine sand occurs in important areas at Chino and north of Bartolo Station on the Los Angeles & Salt Lake Railroad and in two smaller areas southeast of Elmonte.

The surface of the type, while generally level, frequently shows the result of wind action to a slight extent where the soil is not covered by vegetation. Cultivation is very easily accomplished, but the porous nature of the soil makes liberal irrigation necessary. All the type is well drained.

Practically all the Hanford fine sand is in use. Walnuts, alfalfa, and sugar beets are grown on a small scale, in addition to some deciduous fruits. Yields apparently are about the average for the area. Little commercial fertilizer is used on this type. The soil is

deficient in organic matter, the addition of which renders it more retentive of moisture and more productive.

Land prices on the Hanford fine sand range from $150 an acre for unused land to $700 or $800 an acre for land in bearing walnut groves.

In a rather large area west and southwest of Azusa, indicated on the map by stone symbols, the type varies in having large quantities of stones on the surface and through the soil section. This stony variation is little used for agriculture. The surface is gently sloping, but the stony nature of the land makes plowing and other cultural operations, as well as irrigation, difficult. Some citrus groves are being set out on this soil. The price of this land where unused ordinarily is between $50 and $150 an acre. The presence of large stones on the surface lowers the value.

HANFORD SANDY LOAM.

The Hanford sandy loam consists of a brown, friable, micaceous sandy loam, varying in depth from 18 to 24 inches, and gradually giving way to a subsoil that differs from the surface soil only in its slightly lighter brown color. In places no change in the material is noticeable to a depth of 6 feet. Both the surface soil and subsoil are open and porous and easily penetrated by plant roots. The organic-matter content of the soil ordinarily is moderate and in no place high. The type does not carry a large percentage of gravel.

The Hanford sandy loam along stream channels and out in the valley is lighter in texture than in the foot-slope areas. The gravel in the valley usually is rounded, while on the slopes it is more angular.

This type is less extensive than the fine sandy loam, although it occurs in nearly all parts of the area. The principal areas, which are elongated and irregular in outline, are encountered north of Chino, in the vicinity of Covina, and west and south of Monrovia. The type in the trough of the San Gabriel Valley and in the vicinity of Chino was formed by the filling up of stream channels, and lies at a slightly higher elevation than the adjoining soils. Near the foothills it was formed as alluvial fans.

The surface of the Hanford sandy loam is level to only gently sloping, and there is little difficulty in cultivating and irrigating the land. The type is well drained. It is practically all under cultivation. Citrus fruits, alfalfa, deciduous fruits, chiefly peaches, and truck crops are grown. (Plate II, fig. 2.) All these do well. The yields are about equal to those produced on the fine sandy loam. The type is handled in practically the same way. Because of its lighter texture it is necessary to incorporate more organic matter in the soil

and more irrigation water is necessary to insure crops than on the fine sandy loam type.

Land of the Hanford sandy loam has practically the same value as that of the associated fine sandy loam.

HANFORD FINE SANDY LOAM.

The Hanford fine sandy loam in its typical development consists of a brown or light grayish brown fine sandy loam, 20 to 30 inches in depth, underlain to a depth of more than 6 feet by a subsoil which differs little from the surface material except in its generally somewhat lighter brown or grayish-brown color. The soil is smooth and friable; it retains moisture well and is easily penetrated by plant roots. It has a moderate supply of organic matter. Both the surface soil and subsoil have a medium to high content of mica.

The boundaries between this and adjoining types are in some places drawn arbitrarily. Variations from the typical soil, chiefly in color and texture, occur. The texture is not uniform over large areas, the material varying from a loamy fine sand to heavy fine sandy loam. Where the type adjoins areas of the Hanford gravelly sandy loam, its texture frequently is a little coarser than typical and some gravel may be present. Included with the type in some places along streams are shallow deposits of fine sandy loam, underlain by gravel and sand. Filled stream channels usually traverse the larger areas of this type and generally include soils of coarser texture; where these coarser soils are extensive enough to be separated satisfactorily they are mapped with other types. The Hanford fine sandy loam west of Covina and in the vicinity of Chino is lighter in texture than in its typical development, as in the vicinity of Bassett. In a small area just north of Devils Gate the color is reddish brown.

In the southern areas of the Hanford fine sandy loam and in the vicinity of Elmonte and Chino a grayish variation of the type occurs; if more extensive this would probably be classed with a separate series. The soil is light grayish brown when moist and rather grayish when dry. In places it is a fine sandy loam to a depth of 6 feet or more, but generally a subsoil of heavier texture occurs. The subsoil, however, in some places, as near the La Puente School, is lighter in texture than the surface soil, varying from a sand to a sandy loam. The soil of this variation occupies low ridges separated by depressions in which the Chino soils are encountered. South of Elmonte these low ridges roughly parallel the San Gabriel River and the Lexington Wash. In places the water table is high. The same crops are grown on this soil as on that part of the type lying out in the valley.

The Hanford fine sandy loam is one of the most important soils mapped. It is distributed chiefly throughout the central and eastern

parts of the area. The topography is generally level or gently sloping. The surface is somewhat undulating. Cultivation is easily performed, and practically all the type is irrigated. It is generally well drained but in places, especially in the trough of the valley along some of the more important stream channels, the water table is high. The type is seldom overflowed and the inundations are always of only local extent. In the trough of the valley the type is in places subject to erosion by swollen streams, and on the gentle or moderate slopes it is sometimes gullied where not carefully tilled.

The types of agriculture common to the region are practiced on the Hanford fine sandy loam. West of Covina, south of Monrovia, at Lordsburg, and in the vicinity of Pomona, north of the Southern Pacific Railroad, citrus fruits are grown on areas sufficiently elevated to have some protection from frost. The groves seem to develop well, and the yields apparently are equal to the average for the area. Field observations indicate that the heavier soil produces higher yields than where the texture is lighter. Farther out in the trough of the valley, where not enough protection from frosts is afforded for citrus crops, and where the soil is of slightly heavier texture than typical, the type is used to some extent for the production of walnuts.

Alfalfa is another crop produced on the type farther out in the valley. The soil seems to be well adapted to this crop, and good yields are obtained. Dairying is carried on where alfalfa is grown. Trucking is important on this type east of San Gabriel. (Plate III, fig. 1.) A wide variety of garden truck is grown for sale in near-by cities. Deciduous fruits, chiefly peaches, but including also apricots and apples, are grown on the type on a small scale. South of Elmonte and in the vicinity of Chino sugar beets are produced.

The selling price of land of the Hanford fine sandy loam varies greatly, depending upon the state of development and the location. The range is from $200 an acre for new land to $1,000 or more an acre for land in orange groves.

HANFORD LOAM.

The surface of the Hanford loam is a brown, medium-textured loam, 18 to 24 inches in depth. The subsoil consists of a lighter brown, heavy sandy loam or loam, extending to a depth of more than 6 feet. On the slopes near the mountain foothills both the surface soil and subsoil carry considerable grit, while in the areas farther out in the valley the material is comparatively smooth to the feel. Both the surface soil and subsoil are fairly compact and retentive of moisture. The content of organic matter is higher than in any other type of the series. The mica present is more or less finely divided.

Southwest of Covina the soil is very heavy and compact. The type in places on the slopes descending from the foothills apparently contains some reworked material from the Ramona soils. In such places it frequently occurs as a shallow variation from the main type, and has a heavier subsoil.

The Hanford loam is of only moderate extent. It occurs in areas of various sizes between Pasadena on the west and Claremont on the east. The topography is level to sloping. The surface is everywhere smooth and favorable to cultivation and irrigation. In many places the type lies slightly lower than the surrounding soils, and is inundated at times by run-off from adjoining types. The drainage of that part of the type nearer the mountains to the north is good, but farther out in the valley the water table in places is less than 6 feet below the surface.

Practically all the Hanford loam is under cultivation. Most of the type is in bearing groves and orchards. About all the crops that can be grown on the fine sandy loam of this series are successful on this type. The methods of handling, fertilization, and crop yields do not differ greatly from those on the fine sandy loam, and land prices are about the same.

TUJUNGA STONY SAND.

The Tujunga stony sand consists of a grayish to brownish-gray coarse sand, usually carrying a large proportion of gravel and stones, and extending to depths greater than 6 feet. The material is open, porous, and very leachy. It contains more or less mica. The type is low in organic matter and is only fairly retentive of moisture.

The principal area of the Tujunga stony sand occurs along the San Antonio Wash. The surface is quite uniformly sloping and somewhat gullied by shallow channels which carry surplus water. The San Antonio Wash traverses the type for a mile or more from the San Antonio Canyon, where it branches into numerous poorly defined channels, which finally lose themselves in the sand of this type. The soil is excessively drained but is fairly retentive of moisture, considering its open texture. Irrigation and cultivation are difficult, owing to the abundance of surface stones, which must be removed.

The Tujunga stony sand has not been extensively used for agriculture. Recently a few orange and lemon orchards have been set out, largely in the southern part of the principal area of the type, east and southeast of Claremont. Many of the orchards have not yet come into bearing. In farming this soil liberal irrigation and fertilization are necessary to insure good yields, and considerable expense is involved in clearing the land of stones.

Land prices on the Tujunga stony sand range from $50 an acre for unused land to $600 or $800 an acre for land in young groves in bearing.

The addition of barnyard manure and the growing and plowing under of green-manure crops are needed to maintain the organic-matter content and increase the moisture-holding capacity of this soil.

Tujunga stony sand, overflow phase.—The overflow phase of the Tujunga stony sand differs from the typical soil chiefly in its topography and in the scarcity of gravel and stones on the surface. The phase occurs in several moderately large areas forming a part of the overflow plain along the San Gabriel River. The soil is very open and porous, and the water table is high.

The phase is farmed to only a very small extent, owing to the frequent overflows during the rainy season and the open, leachy character of the soil. The raising of hogs is carried on near the larger cities; kitchen waste obtained from hotels and restaurants constitutes the bulk of the feed. The value of this land is relatively low.

CHINO LOAM.

The Chino loam consists of a gray to dark-gray silty loam 24 to 30 inches in depth, underlain by a light-gray subsoil which varies in texture from sand to fine sandy loam or silt loam. The subsoil is stratified, and extends to a depth of more than 6 feet. In small included areas the texture is heavier than typical.

The surface soil generally is moderately friable, although sticky when wet. The subsoil, while fairly compact, is sufficiently open for root development where the water table is not too near the surface. Both the surface soil and subsoil usually are micaceous. The type retains moisture well. Its organic-matter content is generally high. Calcareous material is encountered in the subsoil over much of the type. The Chino loam is lighter colored than the silty clay loam of the series.

This type merges gradually with the Hanford soils, which occur at higher elevations on the gentle slopes, the brown color of the Hanford types grading into the dark-gray color of the Chino soil.

The Chino loam occurs principally in the southern and southeastern parts of the area. The surface usually is level or gently sloping, and all parts of the type can be irrigated and cultivated without difficulty. Some small, shallow depressions occur. While the type is better drained than the Chino silty clay loam, over small areas the water table is high. Surface drainage is not well established, although drainage channels, usually small and poorly defined, traverse the type. In places the land has been tile drained, but the

type has not been improved in this way so extensively as the Chino silty clay loam. In a few places small spots of alkali occur.

The Chino loam is of considerable importance agriculturally. A wider range of crops is grown than on the silty clay loam, including sugar beets, alfalfa, walnuts, grain, and truck. There are a few orchards of deciduous fruits.

Walnuts and alfalfa are grown in the better drained situations, while sugar beets and truck crops are often grown where the soil is not so well drained. Yields are about the same as those obtained on the Chino silty clay loam.

Except for the application of manure on truck crops, little fertilizer is used on this soil. The greater part of the type is irrigated. Some crops can be grown on it without irrigation.

The price of land of the Chino loam ranges from $200 to $500 or $600 an acre.

CHINO SILTY CLAY LOAM.[1]

The typical Chino silty clay loam is a gray to black, compact, sticky silty clay loam, to a depth of 20 to 30 inches. Frequently the surface soil is brownish, especially where the type grades into brown soils. The subsoil usually is gray or dark gray in color. Both the surface soil and subsoil have a high mica content. The soil carries a large quantity of organic matter and generally is moist. The type is quite uniform in texture throughout its extent. Where it borders coarser soils it is lighter in texture and more friable than typical, and in low depressions it is slightly heavier. In the vicinity of Chino the subsoil is a silty clay loam, while south of Elmonte the surface soil is underlain at a depth of 15 to 24 inches by a subsoil of grayish-brown sand or sandy loam. In several areas in the vicinity of Claremont and Santa Anita the subsoil is less calcareous than in the typical development of the type near Chino.

Many small alkali spots occur over the type. These are of only local importance, and, while they reduce the yields of crops, they have not greatly hindered agricultural development. Drainage has done much to reduce the area of alkali accumulation.

The principal areas of the Chino silty clay loam occur south and west of Chino and south of Elmonte. Bodies of less importance occur in the vicinity of Claremont and Santa Anita and in the San Jose Valley. The surface is level or gently sloping, with numerous slight depressions. The type is irrigated. Poor drainage is a characteristic of the Chino silty clay loam. While a number of large and small channels either pass through the type or carry the run-off from it, the water table generally is near the surface and gives rise in places to springs. A considerable part of the type has been tiled.

[1] It is probable that the Chino silty clay loam and its adobe phase along the San Jose Creek, between Elmonte and Spadra, is the Dublin silty clay loam and its adobe phase.

Almost all the Chino silty clay loam is under cultivation. Sugar beets are grown very extensively, and are the most important crop. Yields in the area farmed in connection with the beet-sugar factory at Chino average about 10 tons per acre. Alfalfa is grown to some extent, usually without irrigation. The soil seems to be fairly well adapted to celery, which is grown south of Elmonte. Other truck crops are grown to some extent. Except for small applications of barnyard manure, little fertilizer is used.

The range in price of agricultural land on this type is from $200 to $500 an acre.

Chino silty clay loam, adobe phase.—The adobe phase differs from the typical Chino silty clay loam in its heavier texture and ore compact structure and in origin. This soil if of greater extent would probably be recognized as a distinct type.

The surface soil of the adobe phase consists of a dark-gray to black, heavy clay of adobe structure, ranging from 20 to 30 inches in depth. The subsoil is a mottled gray silty clay loam or silty clay, extending to a depth of more than 6 feet. It varies little from the subsoil of the typical Chino silty clay loam. It is drab in color when moist; upon drying it becomes lighter gray. The surface soil is very compact, and when dry it becomes hard and cracks badly. A good surface mulch can be maintained, however, with proper cultivation. The subsoil is also compact in structure, but where well drained it offers little resistance to the penetration of roots. The phase usually has a high content of organic matter, and it is very retentive of moisture. Calcareous material is present in both the surface soil and subsoil, in the latter generally in large quantity.

The Chino silty clay loam, adobe phase, occurs most extensively in the San Jose Valley. There are some moderately large areas between Puente and Pomona, with a smaller one at Bairdstown, in the western part of the area.

The phase has the surface characteristics of gently sloping, smooth alluvial fans and level river flood plains. It frequently occurs in shallow depressions. The topography is favorable to irrigation. The phase in general is not very well drained, and much of it is subject to occasional overflows. The water table is very often within 6 feet of the surface, although it lies deeper at the immediate base of the low hills.

Almost the entire area of the Chino silty clay loam, adobe phase, is under cultivation. Much of it is used for the production of grain. A part of the type is in walnut groves. Grain seems to thrive where the soil is not too low and wet. The crop is grown chiefly for hay; the yields are above the average for the area. The walnut trees set out on this type have not attained their full growth and can not be taken as an indication of the advisability of setting

out deep-rooted trees on land of this character. Little or no fertilizer is used on this phase.

This land is held at moderately high prices, ranging from $150 or $200 an acre for land used in grain production to $600 or $800 an acre for walnut groves. The area of the phase at Bairdstown, although at present producing grain, has a high value, owing to its proximity to Los Angeles.

The adobe phase of the Chino silty clay loam requires much care in handling to avoid injuring the type physically. The greater part of it requires artificial drainage. The growing of cover crops and the incorporation of organic matter tend to improve the physical condition of the soil.

YOLO LOAM.

Typically the surface soil of the Yolo loam consists of a brown, friable medium loam, ranging in depth from 20 to 30 inches. It varies in texture from a light gritty loam to a heavy silt loam. The subsoil, which is somewhat lighter brown in color, extends to a depth of more than 6 feet, and ranges in texture from a light loam or silty clay loam to a clay loam. Gravel and small stones occur on the type in places, especially along the small drainage ways and bordering gravelly or stony soils. The organic-matter content of the type is moderate. The subsoil, which is more or less compact and retentive of moisture, is deep and offers little resistance to the penetration of plant roots.

In several small areas north of San Dimas the soil varies from the typical in origin, being derived in part from volcanic rocks.

The Yolo loam is not of great extent. It occurs in a few small bodies in the western part of the survey, and in a number of relatively large areas in the San Jose Valley. The surface is level or gently sloping, the gradient being somewhat steeper where the type borders the hills. The topography is favorable to cultivation and irrigation. The type is thoroughly drained, and traversed by well-established channels.

Although the Yolo loam consists in general of recent alluvial-fan deposits, a part of the type approaches the stage of old valley-filling material.

Nearly all the type is in use, mainly for growing grain and alfalfa. Citrus fruits and walnuts are grown south of Puente. The methods of culture are similar to those followed on the Hanford fine sandy loam. The type in the extreme western part of the area is not farmed, owing to its proximity to large centers of population.

The range in the price of land on the Yolo loam is very wide, depending on the location and the suitedness to intensive crops. While unused land in more remote localities can be bought for about $150

an acre, bearing citrus or walnut groves are held at $800 to $1,000 an acre.

YOLO CLAY LOAM.

The Yolo clay loam is somewhat darker than the Yolo loam, ranging from medium brown to dark brown or grayish brown. The subsoil generally is somewhat lighter in color than the surface soil. The surface soil typically is a sticky silty clay loam, ranging in depth from 20 to 30 inches, and underlain by a more compact light clay or clay loam, usually somewhat silty, which extends to considerable depths. The content of organic matter is higher than in the Yolo loam, and the type is more retentive of moisture. Gravel and stones occur on the surface or in the subsoil in places.

The principal bodies of the Yolo clay loam occur at the base of the low hills of sedimentary origin in the western and southern parts of the survey. Large areas are mapped in the San Jose Valley. The surface resembles that of the Yolo loam, being generally smooth and level or gently sloping. (Plate III, fig. 2.) Irrigation and cultivation are easily accomplished. The type is generally well drained.

Grain is the chief crop on this soil in the San Jose Valley, while citrus fruits and walnuts are grown northeast of Puente. Truck crops are grown between the rows of trees to some extent. Some alfalfa is produced on this soil. Its agricultural use is similar to that of the Yolo loam, and the two types are farmed in about the same way.

Little fertilizer is used on this type, except in citrus orchards. Heavy applications have not been necessary, as the trees are still young.

The Yolo clay loam is moderately heavy and is sticky when wet. Plowing under cover crops and organic matter in other forms is beneficial.

Yolo clay loam, heavy phase.—The heavy phase of the Yolo clay loam differs from the typical soil mainly in texture. It is also of somewhat darker color, when moist, resembling the dark-gray to black soils of the related Dublin series. The phase as mapped probably includes some undifferentiated Dublin material, and if of greater extent it would be recognized as a distinct soil type of clay texture. In general it consists of a dark-brown or dark grayish brown, sticky, light clay, about 24 to 30 inches in depth, resting on a dark grayish brown, heavy clay loam which extends to a depth of more than 6 feet. Both surface soil and subsoil are compact, but the structure does not interfere with root penetration except in the poorly drained areas. The content of organic matter ranges from moderate to high.

The heavy phase of the Yolo clay loam is encountered chiefly in the southern and southeastern parts of the area. Several small bodies

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FIG. 1.—STRAWBERRIES GROWING IN YOUNG LEMON ORCHARD ON HANFORD FINE SANDY LOAM NEAR PASADENA.

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FIG. 2.—TOMATOES ON THE YOLO CLAY LOAM NEAR HOWLAND.

occur in the western part. The phase is not extensive. Its surface is smooth and gently sloping. The phase is generally well drained, although in the lower places the water table is within 6 feet of the surface.

Practically all this land is in use. Grain is largely grown in the San Jose Valley and south of Pomona and walnuts in the area north of Puente. Grain apparently is well suited to the soil, and the yields are equal to or slightly higher than those obtained on the residual soils adjoining. The walnut trees are young and have not come into full bearing. The plantings appear to have made a good growth, especially in the well-drained situations. Truck crops are sometimes grown between the rows of trees. These do well and where not cultivated too intensively do not injure the tree growth. Several small citrus orchards have recently been set out on this soil. All the crops except grain are irrigated. Little fertilizer is used, but some barnyard manure is applied.

Land prices range from about $150 or $200 an acre for new land to $800 or $1,000 an acre for land in bearing groves.

The heavy phase of the Yolo loam is sticky, and care in handling is necessary in order to prevent injury to its physical condition. The addition of stable manure and the plowing under of cover crops are beneficial.

ROUGH BROKEN LAND.

Rough broken land includes the steep and rough areas of hill and mountain land and the rough and eroded escarpments along areas of old valley-filling soils, occurring usually near the mountains to the north. The soil is not so stony as is Rough stony land; as in the case of that type, however, it includes undifferentiated materials.

Most of the Rough broken land occurs in the southern and western parts of the area and is derived almost entirely from sedimentary rocks. The type in the northern part of the area is largely of granitic origin, with some volcanic-rock material included north of San Dimas. Along the base of the mountains remnants of old valley-filling material give rise to the Rough broken land.

The soil in general is somewhat deeper than in the areas of Rough stony land, and more of the Rough broken land is arable. The value of the land in various places depends largely upon the possibility of irrigation.

The Rough broken land generally is treeless in the western, central, and southern parts of the survey, but there is more or less tree growth in the larger areas in the northern part. The land is dissected and eroded to such an extent that agriculture is unprofitable at the present time. It is devoted largely to grazing horses and cattle.

The value of this land is only a few dollars an acre in the more remote situations; that land located near the large cities commands high prices.

ROUGH STONY LAND.

Rough stony land consists of areas in which the topography is too steep and the surface too stony and rough for tillage operations. It is restricted largely to the lower slopes of the San Gabriel Mountains. Several areas occur in the vicinity of Pomona, in the San Jose Hills.

The soil material is residual in origin and usually very shallow. It is derived almost entirely from granitic and gneissic rocks, but north of San Dimas and west of Pomona the soil-giving formations include some volcanic rocks, and south of Pomona sedimentary rocks give rise to small areas. Outcrops of the parent rocks are numerous.

The greater part of the Rough stony land bordering the area on the north supports a forest growth and furnishes some pasturage for stock. There are some patches of tillable land; their value depends very largely upon the possibility of irrigation. The Rough stony land west and south of Pomona is unused except for the scant grazing it affords for horses and cattle.

The value of this land usually is very low, except where used for building sites along the stony canyons and at the foot of the mountains. It is used rather extensively in this way in the northern part of the area.

RIVERWASH.

Riverwash consists of areas of undifferentiated alluvial deposits along stream channels, where the land is subject to frequent overflows. The soil generally is very coarse and stony, the fine material having been washed away.

Riverwash occurs in all parts of the area, but most extensively in the trough of the valley along the San Gabriel River. It also occurs along the San Antonio, San Dimas, and Eaton Washes and the Arroyo Seco.

The areas slope with the gradient of the associated streams, usually becoming wider as the trough of the valley is approached. The surface is stonier near the mouth of the canyon, and in the valley the deposit frequently consists of coarse, clean sand. Additional material is being deposited continually and areas of Riverwash frequently extend back into the agricultural land along the streams. Occasionally small areas of agricultural land are separated from the main tracts by river deposits.

The water table is very near the surface, and trees and shrubs that thrive where the water table is high constitute the only natural growth.

Riverwash has little value for agriculture, owing to its coarse texture and frequent inundation.

Much is being done to protect this land from overflow by artificially confining the streams to their channels. In some cases Riverwash has been reclaimed and made productive. The value of the land in its natural condition is low.

IRRIGATION.

Irrigation is necessary in the production of most of the crops grown in the Pasadena area, except in the stream bottoms and where the soil is kept moist by seepage. Irrigation was carried on in a crude way by the early mission fathers, but the first important projects came with the establishment of the more recent types of agriculture.

Water for irrigation is obtained from streams issuing from the canyons in the San Gabriel Mountains, is pumped from underground basins or is obtained from flowing wells and springs. Many small storage reservoirs have been established throughout the area on the mountain foot slopes.

The San Gabriel Mountains form the source of the only perennial streams in the area. The snowfall melts slowly in protected places and furnishes a more or less constant supply of water. The 1910 census reports 46,754 acres of land in Los Angeles County irrigated from streams. Practically all this acreage was supplied through gravity canals. Water from this source is in general applied to lands lying on the mountain foot slopes and in the vicinity of the larger canyons. The San Gabriel River is the stream of largest flow, but its discharge varies greatly at different seasons of the year as well as in different years. Other streams of importance as sources of irrigation water are San Antonio, San Dimas, and Eaton Creeks. San Jose Creek, in the southern part of the area, maintained a flow in the summer, before the settlement of the valley.

More land in Los Angeles County is irrigated by means of pumping plants than in any other way. The area supplied in 1909 amounted to 83,813 acres, and the census reports 1,361 plants in the county. Pumping outfits are operated throughout the agricultural part of the Pasadena area, the greatest number being in the vicinity of Lordsburg, Claremont, and Pomona. They have been established chiefly on the valley floor, but also on the mountain foot slopes. A large supply of water is available for pumping, especially in the vicinity of the washes.

Only a small acreage is irrigated from flowing wells. Several artesian belts occur within the area; the largest one is southwest of Chino. Smaller belts occur south of Santa Anita and southeast

of Ramona. There are few springs in the area, and water from this source is used for irrigation only over small areas. Springs in the mountains to the north furnish water for stock. The small reservoirs at the bases of the mountains, especially in the northwestern part of the area, are, as a rule, fed by springs. They supply water chiefly for domestic purposes and have little bearing on the irrigation of agricultural lands.

In 1910 there were 1,567 independent irrigation enterprises in Los Angeles County, operating 601 main ditches, with 494 laterals. The distributing systems are very substantially constructed, much of the water being conducted underground through cement or metal pipes, with little loss by seepage. The average cost of the projects per irrigable acre is reported by the 1910 census as $42.60 and the average cost of operation and maintenance in 1909 as $5.31 per acre.

All crops, except dry-farmed grain, require irrigation throughout a part or all of the growing season. Water must be supplied liberally to citrus crops, except during the rainy period. Walnuts, deciduous fruits, alfalfa, and general farm crops in the course of a season require from two to seven irrigations, and much water is used in growing truck and garden crops. The methods used in irrigation are described in detail in Water Supply Paper No. 219, issued by the U. S. Geological Survey.

The practice of charging the water users in proportion to the quantity consumed tends to prevent not only the waste that frequently occurs in irrigated districts where water is cheap, but also the injudicious use of water in the higher areas, which has resulted in injury to lower lying lands in many irrigated regions.

ALKALI.

Over the greater part of the Pasadena area the land is sloping and well drained, and conditions do not favor the accumulation of alkali salts. No large bodies of land are rendered worthless for agriculture by the presence of alkali, but certain areas in the vicinity of Chino and to the south of Elmonte are affected to some extent. The alkali occurs in spots ranging in diameter from a few feet to a rod or two. The affected spots constitute the smaller proportion of the areas in which they occur, and between them the land apparently is very little injured. Areas in which alkali has accumulated are shown on the soil map by symbol. The Chino soils are affected more than any other.

In the vicinity of Chino, where the largest areas of alkali-affected soil occur, much of the land has been tile drained and the water table lowered from near the surface to a depth of 4 or 5 feet. South of Elmonte, in the section of the area just north of Bartolo Station, the subsoils are very coarse and light in texture; while the

water-table level frequently is very near the surface and some alkali deposits occur, it is not likely that the soils here will ever be badly affected. The slope of the land and the porous subsurface strata are favorable to the lateral movement of the underground water, and for this reason the accumulations here are confined very largely to the upper 1 or 2 feet of soil.

Alkali accumulation is the result of the rise of ground water to the surface by capillarity, with concentration of the salts on the surface upon the evaporation of this moisture. The salts so deposited usually are derived from water which contains them in only very small quantity, and which is otherwise useful for irrigation. Sodium carbonate, sodium chloride, and sodium sulphate are the common harmful salts in alkali accumulations. Sodium carbonate generally is known as black alkali because of its corrosive action on organic matter, producing a black color in the presence of moisture.

The presence of alkali reduces the yield of crops and causes an irregular stand. Sugar beets are the chief crop produced on soils so affected. This crop is quite tolerant of alkali, although lower yields are noticeable where the concentration is high.[1]

SUMMARY.

The Pasadena area occupies that part of the southern California valley lying between the San Gabriel Mountains on the north and the Puente Hills and associated ranges on the south, and extends from the San Rafael Hills on the west to the meridian of Ontario on the east. About one-tenth of the area of Los Angeles County is included, and a small part of San Bernardino County. The area covers about 423 square miles, or 270,720 acres.

Parts of the San Gabriel Mountains, of the San Rafael and Puente Hills, the San Jose Hills, the San Gabriel and tributary valleys, and a part of the Cucamonga Plains constitute the area surveyed. The adjacent rough, forested mountains attain an elevation of over 6,000 feet above sea level; the other sections are low and rolling, including land suitable for grain growing and pasture. Elevations within the area range from about 225 feet to over 2,000 feet above sea level. The San Gabriel Valley and the Cucamonga Plains are the most important agricultural parts of the survey.

The area is drained by three principal systems. The San Gabriel River with several tributaries drains the mountains and the valley of the same name. La Canada Valley is drained by the wide and deeply cut Arroyo Seco and by the Verduga Wash, both of which flow into the Los Angeles River. That part of the area east of the San Jose and Puente Hills is drained by Chino Creek, which flows

[1] See Bul. 35, Bureau of Soils, Alkali Soils of the United States.

into the Santa Ana River. No distinct channels connect the mountains with this creek.

The inhabitants of the Pasadena area are chiefly native white. The settlement is comparatively dense. Los Angeles lies partly within the area. Pasadena and Pomona are the largest included cities. Many towns of smaller size are commercial centers. There are excellent transportation facilities in nearly all parts of the area.

Cities within the area and in other parts of southern California constitute the chief markets for the agricultural products. The citrus crop is marketed throughout the United States and abroad.

Pleasant weather prevails throughout almost the entire year. The climate is characterized by a wet and a dry season. Crops sensitive to frost are grown in thermal belts along the mountain foot slopes. The mean annual temperature for the area is about 63°. The precipitation varies widely, extremes of 6.45 and 29.42 inches per year having been recorded. It averages probably between 15 and 18 inches.

Agriculture in the area began about 1773, when the Mission Fathers first planted grain and garden crops. The growing of European grapes was important in the early agriculture. The establishment of gold camps throughout the State about 1850 stimulated farming. About 1870 viticulture gave way to the present type of agriculture, under which fruit crops, hay, and truck are the principal products.

Citrus fruits are the most important crops grown. The possibility of irrigation has largely influenced citrus-fruit culture. The principal varieties of oranges are the Washington Navel and the Valencia. Clean cultivation usually is given, and green and animal manures and fertilizer are used to maintain soil productiveness. Citrus fruits are harvested throughout the year. Large capital and good organization have raised the citrus-fruit industry to a position of great prominence.

Walnuts are grown extensively on soils too cold for citrus crops. No fertilizers are used for walnuts; the groves are irrigated. The peach is the principal deciduous fruit grown. Clean culture is practiced in the orchards. Little fertilizer is used. The apple is an unimportant product. A few vineyards of grapes are still in bearing. Grapes are grown without irrigation.

The growing of grain for hay is an important industry in the rolling foothills in the southern part of the area. Barley, oats, and wheat are grown to a small extent for grain. The yields are low. Alfalfa is produced with irrigation in the central and southern parts of the valley on well-drained soils of the valley floor. Five to seven cuttings a year are obtained.

Truck crops are produced in the vicinity of the larger cities and towns, generally by foreigners. Several crops are grown on the same field in the course of the year. Soil productiveness is maintained by the use of manures. Sugar beets are grown on soils whose drainage is sometimes imperfect. Irrigation is necessary in their production.

Raising live stock is of less importance than the growing of fruits and field crops. Dairying is important. Poultry raising is carried on more or less extensively to supply the local markets. Horses and mules are raised for sale. Beef and pork production is carried on to a small extent.

Topography is a very important consideration in the selection of sites for planting fruits sensitive to frost.

The size of the farm is influenced by the character of the soil, irrigation possibilities, and the location. The larger farms occur in the areas of residual soils. Citrus plantings are held largely in tracts of 5 or 10 acres. Most of the farms contain less than 50 acres and most of them are operated by the owners. The range in land prices is very wide.

The soils of the Pasadena area are derived predominantly from granitic and associated rocks of the San Gabriel Mountains. Soils derived from sedimentary shales, sandstones, and conglomerates occur in the western, central, and southern parts of the area. Soils from volcanic rocks are of very small extent.

The residual soils are confined largely to the mountain and hill lands. Water-transported soils cover the remainder of the area and consist of both old and recent valley-filling material. The old alluvium occurs as undulating valley plains or as remnants of the older plains surface, now largely removed by erosion, along the foothills. The recent valley filling occupies most of the alluvial-fan slopes and valley floor.

The residual soils are classed with the Altamont and Holland series. The Altamont soils are devoted to grain production and grazing, while the Holland soils are little used for agriculture and furnish only sparse grazing. The agricultural value of the residual soils depends almost entirely upon the soil depth, the topography, and the quantity of stones present.

The soils derived from old valley-filling material are classed with the Ramona, Placentia, and Antioch series. The Ramona soils are extensive and, except in the case of the stony and gravelly types, are widely used for citrus-fruit production, as is also the Placentia loam. The Antioch silty clay loam is used for the production of grain hay.

The Hanford, Tujunga, Chino, and Yolo series comprise the soils derived from recent valley-filling material. The Hanford soils cover

a large part of the area and are important agriculturally, being used for the production of citrus fruits, deciduous fruits, walnuts, truck, and other crops. The Tujunga stony sand is not an important type. The Chino soils are used to an important extent for growing sugar beets, and also produce walnuts, alfalfa, truck crops, and other crops. The Yolo soils are used largely for growing grain, walnuts, and alfalfa in addition to citrus fruits and other crops.

The miscellaneous classifications, Rough broken land, Rough stony land, and Riverwash, mainly are nonagricultural.

Irrigation is necessary in the production of most crops, although grain is dry farmed. Irrigation water is obtained from streams issuing from the mountains, from flowing wells and springs, or by pumping. The irrigation works are substantially constructed.

Alkali accumulations occur in places in the southern and southeastern parts of the survey, mainly in areas of the Chino soils. Only a small total area is affected. Sugar beets are the principal crop grown on alkali soils.

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[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

Areas surveyed in California.

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U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY
SOIL MAP
CALIFORNIA
PASADENA SHEET
UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
THOMAS F. HUNT, DIRECTOR
CHARLES F. SHAW, IN CHARGE SOIL SURVEY
SOIL PROFILE
(6 feet deep)
LEGEND
ANGELES NATIONAL FOREST
SANTA ANITA
AZUSA
DUARTE
SAN JOSE ADDITION
SAN FRANCISQUITO
POTRERO GRANDE
LA MERCED
SAN ANTONIO
PASO DE BARTOLO
SAN RAFAEL
LOS ANGELES
SANTA ANA DEL CHINO
RINCON DE LA BREA
CONVENTIONAL SIGNS
Contour interval
Datum is mean sea level
Macy H. Lapham, Inspector, Western Division.
Soils surveyed by E. C. Eckmann, of the
U.S. Department of Agriculture, in charge,
and C. J. Zinn, of the University of California.
BASE MAP FROM
U.S. GEOLOGICAL SURVEY SHEETS
Field Operations
Bureau of Soils
1915